DOCUMENT RESUME

ED 367 570 SO 023 719

AUTHOR Byrne, Eileen M.
TITLE Women in Science and Technology: The Institutional Ecology Approach. Volume I: Final Research Report.
PUB DATE Dec 92
NOTE 240p.; For volumes 2 and 3, see SO 023 720-721.
AVAILABLE FROM Eileen M. Byrne, Department of Education, University of Queensland, QLD 4072, Australia ($25 Australian).
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC10 Plus Postage.
DESCRIPTORS *Females; Foreign Countries; Higher Education; Mathematics; *Role Models; *Science Careers; *Sciences; Secondary Education; Social Science Research; *Technical Education; *Technology
IDENTIFIERS Australia; *Women in Science and Technology in Australia

ABSTRACT

This document is the final research report of the University of Queensland Women in Science and Technology in Australia (WISTA) project. The report is a policy review study conducted from 1985 to 1990, of the factors that act as critical filters or positive factors that hinder or help women's access to and progression in certain scientific and technological disciplines. The report draws on a major review of published research, specially collected statistical data, and group interviews with professors, deans, and school heads based on a set of discussion papers dealing with the 10 core factors that provided the central theoretical framework of the WISTA project as a whole. These factors are: (1) same sex role models as a positive influence for women; (2) mentors; (3) image of different branches of science and technology; (4) male and female attitudes toward women in "nontraditional" disciplines; (5) single sex versus coeducation; (6) prerequisites and curricular choice as critical filters; (7) math as a critical filter; (8) career education and guidance; (9) women's support networks; and (10) affirmative action intervention. These 10 factors in turn are related to 4 concepts of wider significance, namely: institutional ecology, critical mass, attribution of disciplines as male or female and the constructed style and content of scientific and technological disciplines. The findings and conclusions include such challenges to current received wisdom as: (1) that use of personal same sex role modeling is an ineffective and inappropriate policy mechanism; (2) that mentorship is an influential but still unacknowledged and underestimated policy mechanism in higher education; (3) that a major paradigm shift is needed from examining girls and women to examining the institutional ecology and the ecological niche of disciplines; (4) that single sex school education does not advantage the mainstream of girls in nontraditional science and technology; and (5) that mathematics remains a critical filter, but contains a further filter giving girls a different mathematics profile from boys at grades 11 and 12. (DK)

Permission to reproduce this document
has been granted by Eileen M. Byrne
to the ERIC Resources Information
Centre in any form suitable or
appropriate. Eileen M. Byrne
20. 7. 93.

ED 367 570

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
EILEEN M. BYRNE
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SO 023 719

BEST COPY AVAILABLE

PREFACE

This is the final report of the ***University of Queensland's*** ***Women in Science and Technology in Australia (WISTA) Policy Review Project****. This is one of three WISTA projects, which has reviewed factors which help or hinder women's access to and progression in science and technology in higher education in Australia.*

The ***UQ WISTA Policy Review Project*** *was developed under the direction of Professor Eileen Byrne, Professor of Education (Policy Studies) at the University of Queensland, over the years from 1985-1989. It was based on a sample of ten higher education institutions across Australia and on a major policy research review of a range of factors and policy issues, in the context of the development of new mid-range policy theories. The Queensland WISTA project is independent of the other two WISTA projects, and all conclusions and theories developed from it in published work are the sole responsibility of Professor Byrne.*

The overall WISTA project was initiated by Dr Elizabeth Hazel of the School of Microbiology of the University of New South Wales, who directed two concurrent WISTA projects at the University of New South Wales: an interview-based brief study of a sample of working women and men scientists and technologists, and a questionnaire-based study of students in scientific and technological disciplines at the University of New South Wales and the New South Wales Institute of Technology (now the University of Technology, Sydney).

The major findings of the UQ WISTA Policy Review Project are published in Women in Science: the Snark Syndrome, Falmer Press, 1992.

ACKNOWLEDGEMENTS

Acknowledgement is made to the four sponsors whose grants totalling $77,264 made the UQ WISTA Policy Review research possible: the Australian Research Grants Committee and Australian Research Council, The University of Queensland, the Myer Foundation and the Commonwealth Tertiary Education Commission. My principal debt is to the research team, Merideth Sadler, Senior Research Assistant and Marie Keynes, Project Officer and Secretary, without whose constant efficiency, reliability, insights and support, the scale and complexity of the research would have been impossible.

Thanks are due also to Dr Elizabeth Hazel, Senior Lecturer in the School of Microbiology at the University of New South Wales, to whose initiative and energy the overall three-stranded Women in Science and Technology in Australia Project (WISTA) owes its original foundation in 1984 and its early funding, before the Policy Review Project moved to The University of Queensland under the direction of Professor Eileen Byrne in 1985. It was renamed the UQ WISTA Policy Review Project and provides the basis for this Research Report. We thank the Vice Chancellors, Directors, Registrars of the ten UQ WISTA survey institutions for their constructive cooperation and their supply of a wide range of institutional data, much of it especially prepared for this Project; the Deans, Professors, Heads of Schools and academic and professional staff who attended the group interviews in the ten survey institutions, responded to written Discussion Papers, and subsequently supplied other relevant data. Their views, experience and evidence have helped to shape both interim and final policy recommendations.

A particular debt is due to the Board of Secondary School Studies, Queensland; the New South Wales Department of Education's Secondary Boards Directorate; the Victorian Curriculum and Assessment Board; the Senior Secondary Assessment Board of South Australia; the Secondary Education Authority of Western Australia; the Schools Board of Tasmania; and the Australian Capital Territory Schools Authority, for data, much of it unpublished, on Grade 12 enrolments and for further background on curriculum content of Grade 12 subjects.

Dr David Chant, Statistical Adviser to the Social Sciences Group of the University of Queensland has given much helpful advice and guidance on the statistical analyses and on the computerisation and analysis of the student and staff data.

CONTENTS

Page

Chapter I: Introduction 1

Chapter II: Methodology: A Holistic and Policy Approach 30

Chapter III: Institutional Ecology and Women in Science 52

Chapter IV: Where Women Are, and Where They Aren't: Institutional and Disciplinary Differences 79

Chapter V: Role Modelling as a Policy Mechanism: Poor Evidence for the Theory 112

Chapter VI: The Mentor Process: Embedded, Unacknowledged, but Critically Influential 155

Chapter VII: The Formative Years: Pre-Tertiary Influences: Single-Sex, Maths, Image 181

Chapter VIII: Conclusion: Policies for Change? 214

CHAPTER I

INTRODUCTION

> ***"There is no such thing as a female mind: as well talk of a female liver."***
>
> Charlotte Perkins Gilman, 1890

This is the final research report of a lengthy policy review project which set out to examine the barriers which filtered women and girls out from scientific and technological disciplines, and the positive factors which helped their access and progression. But this project, the University of Queensland Women in Science & Technology in Australia Review Project (UQ WISTA) has not, unlike much previous research, focussed on the *alleged* deficits in girls and women themselves (the "blaming-the victim" approach), but on the factors ***within the institutional ecology of higher education institutions*** themselves, and within school ecology, which act as positive and negative mechanisms, both in terms of *access*, and of *progression.*

The ideas and research on which the research is based represent a critical review of current received wisdom on the position of women in (or out of) science and technology, in the context of policy for change. The research was based on two major paradigm shifts. Firstly, the research focussed on institutional ecology (the responsibility of the gardener for how plants grow...) and not on the deficit model of pulling girls up by the roots at intervals to examine why they don't fit the preset ecology; and secondly, on the hypothesis that the "problem" with girls and women is boys and men. That is, it is male behaviour, male attitudes and a "male-as-norm" ecology which acts as an embedded, a structural and a cultural filter. This will be developed in detail throughout this report.

When the research on which the main conclusions of this report are based was designed in 1985, it became very evident in the first comprehensive literature search that, despite a decade of scholarly research in the area of women and science, too much of what passes for current received wisdom in educational policymaking and in teaching theory in relation to women and science, has still been based on very imperfect policy theory. By dint of repetition three times (or thirty), the educational community has internalised an oversimplified and often unscholarly selection of beliefs and premises which have descended to the "everyone knows that... " level of slogan-like impact. For example, current in most educational reviews and policy reports, are such generalised imprecise assertions as that if only we had more women role models, we would have more women students; that single-sex education advantages more women students; that single-sex education advantages girls; that conversely coeducation equips girls better; that girls can't/don't do maths as well as boys because of maths anxiety, or because of differential teacher attitudes, or because of innate genetically-inherited differences in spatial ability, or because they don't have the same childhood practical learning experiences as boys. These statements are at best only partly true, and only valid in certain specific circumstances. Many of the asserted "principles" on which current educational policy is built, are also based on assumptions as unfounded as the nineteenth century New Zealand teacher who justified and defended teaching mathematics to his girls not because he saw them as future physicists, but because "he regarded mathematics for girls not only as useful in everyday life, but also essential to prevent their natural tendency to be 'birdwitted'" (Wallis, 1972). One is reminded of the view of Hypatia (c.370-415) that "men will fight for a superstition quite as quickly as for a living truth - often more so, since a superstition is so intangible you cannot get at it to refute it, but truth is a point of view and so is changeable".

This is essentially a policy report. It reviews research on women and science, and reports on a major and complex research project which investigated positive and negative factors which appear to help and hinder women's access to and progression in science and technology in Australia. But it does so in a strictly policy context, and seeks to re-analyse current received wisdom and current scholarly and well founded research findings, in direct relation to their implications for changing educational policy. As a result, both the design of the research we report, and its outcomes, support some paradigm shifts in the way in which we define the problems and issues, and the way in which we interpret data, in relation to women and science.

Australia's economic future remains partly dependent on our developing our own manufacturing technology, information technology, scientific innovation and invention. The wastage of scientific and technological talent from the girls and women who represent 51 per cent of the population must be a matter of social, economic and political concern. In Australia, Federally commissioned committees on education, training and employment and on technological change respectively, have both recorded extreme concern at Australia's failure to recruit and develop female talent in science and technology, particularly at tertiary levels (Williams Committee [1979] and Myers Committee [1980]). The Kangan report on technical and further education in Australia had recorded a similar message of failure to invest in and encourage female talent (ACOTAFE, 1974). But in 1984, Australia was seen to be "well behind comparable countries in national initiatives addressing the problems for girls in these (maths and science) areas of the curriculum" (Commonwealth Schools Commissions, 1984), while two years later, the Commission recommended that "schools should provide a challenging learning environment which is socially and culturally supportive and physically comfortable for girls and boys" (Commonwealth Schools Commission, 1987, p.70).

The UQ WISTA project was not, therefore, primarily driven by equity objectives, sound though these may be, but by the policy objective of increasing Australia's pool of skilled graduates in science and technology. But it is not only a matter of loss of skilled womanpower. It is also a question of general scientific literacy; of the participation of all adult people and not only adult males, in the judgemental process involved in applying the results of science and technology to governmental policy. Twenty years ago, the Dainton Committee were saying that "Those who have no scientific understanding are cut off from a great human activity; and may well feel excluded from intercourse with those who have such understanding" (Council for Scientific Policy, 1968). In 1985, the UK Inspectorate, writing of policies for school science, endorsed a much-repeated view that "the failure of many girls to acquire a broad education in the main areas of science means that they are deprived of essential skills and knowledge, and the nation loses scientific and technological expertise" (Department of Education and Science, 1985[a]). Women engineers in France have reasserted their conviction that decisions in science and technology policies need also to be influenced by the experience and insights of women as well as men:

> "This responsibility (for the consequences of technology) is of the utmost significance for the women scientists and the women engineers. On the one hand, they are in a better position to convey a knowledge acquired through personal experience to a seldom well-informed public opinion. On the other hand, they have to make womankind realise that they should not remain unconcerned in a world ruled by technique, but that they have a part to play in it." (Cercles des Femmes Ingénieurs, 1978).

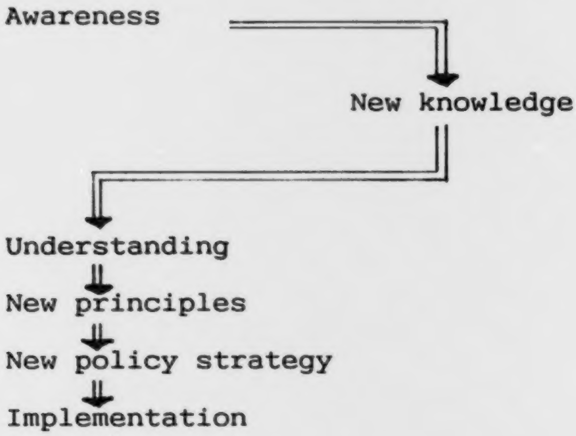
Before we look at several areas of substantive theory which have been reviewed in the UQ WISTA project, we first set out its main framework and scale.

A Policy Issue

The project was a policy project. Its two main general objectives were the construction of improved policies and the application of new or improved theory to current practice. It worked through two dimensions: a scholarly review and policy analysis of existing and earlier research on influential factors in the context of the reconceptualisation of some current received wisdom; and a partly empirical survey of ten Australian higher education institutions.

The project looked at five Universities and five Institutes of Technology from 1985 to 1989, (a) in the context of the sample of Australian institutions from which to investigate the statistical sexbalance and characteristics of different disciplines within science and technology; and (c) as a catchment area for testing current professional opinion on the core ten factors (and possible new factors) which form the central theoretical framework for the WISTA project as a whole. It focusses on the policy implications of the investigated areas.

If rational policymaking is to produce efficient returns for investment, it should follow a sequential, phased process as set out below. Much policy in higher education (both at institutional and governmental system levels) has in fact jumped one or more stages either in the interests of speed and expediency or because of an inability (or unwillingness) to define and agree on new principles.



Ten core factors: a central framework

Very early in our literature review and search, and after preliminary analyses of what limited statistical data were available for Australia, two things became evident. Firstly, there was a core of factors (not of equal importance) which were cited by almost all overseas countries which had mounted relevant research. Reports from the major international organisations endorsed most of these as widely relevant. Whatever the ultimate relevance or influence of these might prove to be in our Australian study, clearly they could not be ignored and should form the basis of one central set of issues to be investigated. They can be summarised as:

- same-sex role models as a positive factor of influence for women

- the mentor process, potentially negative or positive

- the image of different branches of science and technology (male, female or sexneutral; socially responsible or systems and machine-oriented)
- male attitudes to females in "nontraditional" disciplines; female attitudes (self-esteem, or towards peers)
- single-sex versus coeducation as positive or negative influences
- prerequisites and school patterns of curricular choices as critical filters
- mathematics as a negative critical filter
- careers education and vocational counselling as positive or negative influences
- women's support networks as positive influences
- affirmative action projects in science and technology as positive influences.

These, referred to hereafter as **the ten factors**, have formed a major part of our theoretical framework. Diagram A illustrates how we are relating these to four concepts or dimensions of wider significance, that is

- institutional ecology
- critical mass
- the perceived "masculinity" or "femininity" of disciplines
- the constructed style and content of scientific and technological disciplines.

It will be seen from Diagram A that an intersection point (of hypothesised interrelationship) is shown only between some factors or concepts. Thus, for example, image is seen as related to institutional ecology, male or female attribution and the construction of disciplines but not to critical mass; and so on.

Related-factor strategies: not linear programmes

It was clear both from the specific literature review completed in this project in the first year of the project, and from the writer's decade of previous researches and reviews in the area of women, education and training, that the major flaw in much of the relevant previous published research, was that it looked only at one, sometimes two, factors or aspects of a problem in isolation. Approaches have too frequently been linear and narrowly focussed on the somewhat specious grounds of feasibility. But much inaccurate and unscholarly "received wisdom" has been disseminated into the education system and used as a basis for future policies, based on narrow, single dimensional studies. This does not necessarily rule out the usefulness or scholarship of narrow linear studies but it requires greater academic responsibility in publication to point either to the limits of the evidence or to its nontransferability in empirical terms. Thus assertions have been made about the influence of issues such as same-sex role models, single-sex schooling and coeducation, prerequisites, mathematics etc, on very constrained empirical evidence and without moderating for other related essential and controllable factors. This report challenges some current received wisdom in this regard.

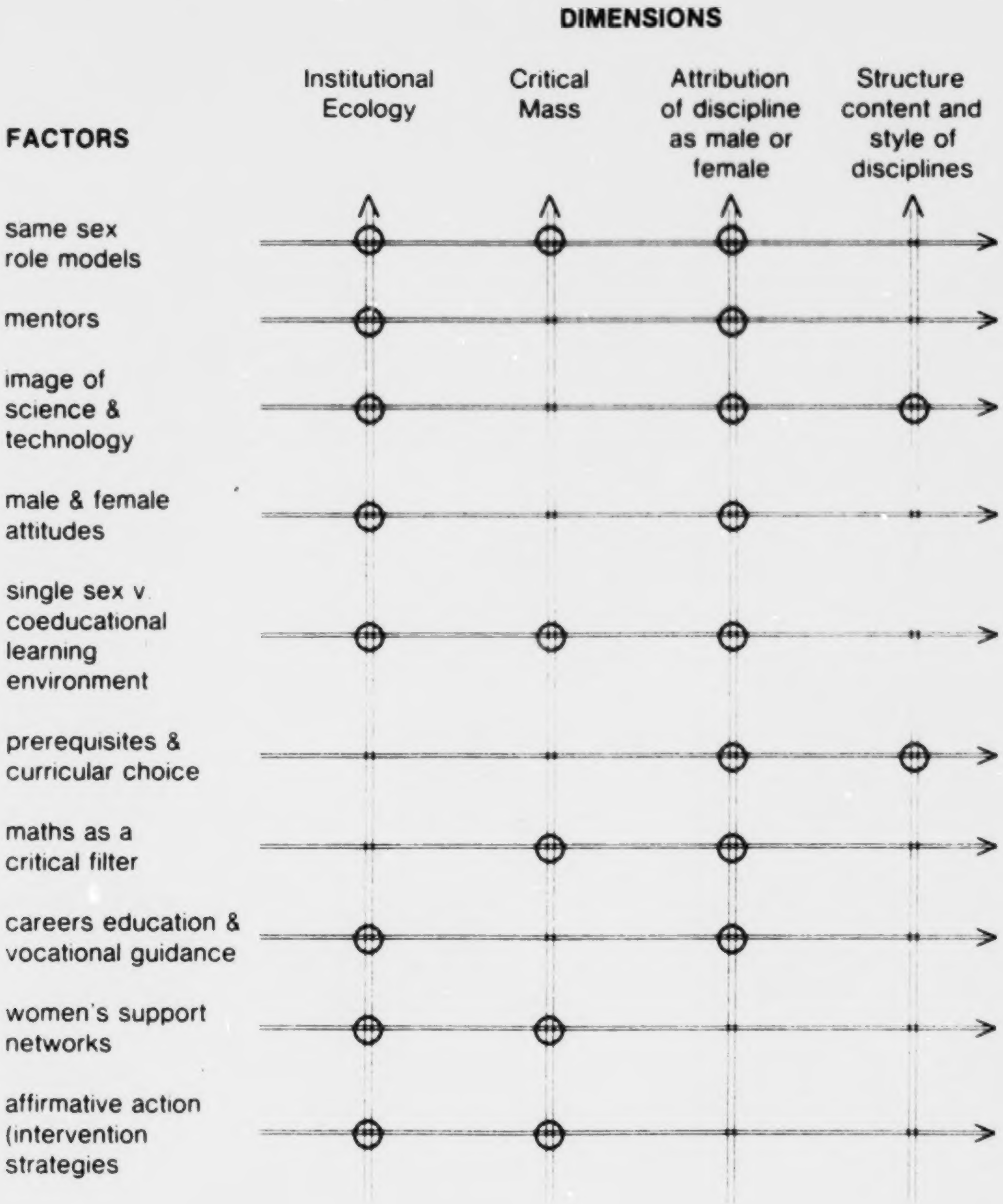
Our research has been based on the hypothesis that the core factors listed in the diagram grid of our theoretical framework illustrated in Diagram A, need also to be analysed in terms of **clusters of relevance and interrelationships** and should lead to integrated policy strategies, not single-dimensional programmes tackling only one issue.

Access and progression

Access is one thing. Retention and progression are another. Research literature has for over a decade now across many countries and cultures, recorded the phenomenon of "cascading losses". That is, institutions record a cumulative and progressive loss of female enrolments as one moves up levels of the education systems.

Isabelle Deblé, for example, cites an IEA study of 1974 into results of boys and girls in physics, chemistry and biology which showed that at the start of schooling, the difference between the sexes is minimal. The gap between the results, however, grows steadily as they get older, according to sex. Her own study of thirty-nine countries analysed female:male enrolments and wastage and found that ratios were always higher for boys at the "third level" (tertiary study) except in some parts of Europe and the USSR (Deblé, 1980). Women are proportionately fewer at each level and stage of education; relatively fewer in tertiary than in secondary; and fewer in postgraduate than in undergraduate studies; fewer in PhD enrolments than at Master's level (Byrne, 1978; Cass, 1983; OECD, 1986). A review of sixty-two studies looking at science and maths education in the UK also noted the "cascading effect" of progressive losses of female participation related to male, throughout the educational system up to the beginning of tertiary study (Kaminski, 1982).

The project therefore particularly also focuses on policy issues and factors which influence women's progression from



FACTORS	Institutional Ecology	Critical Mass	Attribution of discipline as male or female	Structure content and style of disciplines
same sex role models	⊕	⊕	⊕	
mentors	⊕		⊕	
image of science & technology	⊕		⊕	⊕
male & female attitudes	⊕		⊕	
single sex v. coeducational learning environment	⊕	⊕	⊕	
prerequisites & curricular choice			⊕	⊕
maths as a critical filter		⊕	⊕	
careers education & vocational guidance	⊕		⊕	
women's support networks	⊕	⊕		
affirmative action (intervention strategies	⊕	⊕		

Figure UQWISTA theoretical framework first year undergraduate studies to specific subdisciplines (biochemistry as distinct from chemistry, applied geology etc) and from undergraduate to postgraduate studies. Hence such issues as the mentorship role are reviewed, as well as statistical patterns of student enrolment.

SHIFTING THE PARADIGMS

The theoretical framework of this review took several shifts in focus as a starting point. Both the results of the critical review and the findings of our ten-institutional survey now justify several major paradigm shifts. These apply both to future research priorities and as a basis for future policies.

(a) From victim to cause: from female to male

The most substantial body of relevant previous research has focussed on girls themselves as a means of finding out why they drop out, underachieve, or indeed, why they succeed. This has been a useful and necessary first step in order more accurately to identify possible barriers and factors of influence. But the first two rounds of this research exercise have shown clearly that the problem lies mainly not with girls and women, but with boys and men. For it has been predominantly the men in schooling, science and industry who have created masculine images and attached them territorially to disciplines and occupations. It is primarily male students who define women students as normal or abnormal in a discipline; who assert exclusive territoriality; who dominate hands-on experimentation with equipment and computers to exclude girls and women.

It is the men in the leadership of higher education who (albeit often unconsciously) mentor male but not female students, to the great advantage of the former.

These issues are factors which critically affect the learning environment of girls and women. One fundamental approach which has underpinned the UQ WISTA research from its outset, therefore, has been a belief that we need to move from the blaming-the-victim approach of constantly dissecting the behaviour and attitudes of girls to find explanations of lack of access and progression, to examining the education systems in which they locate, as a mainstream explanatory theory. We believe that real explanations belong in the **ecology** of their teaching and learning environment; but that this ecology functions at institutional level and not only at the level of the classroom or discipline (or "ecological niche"). Hence our focus on the concept of **institutional ecology** as an explanatory theory.

From generic science to a discipline-based model

Some of the value of research in the 1960s and early and mid 1970s is diminished by an inadequately diagnostic approach to science in relation to women's participation. Much research, for example, writes incorrectly of female access to "science" as if this were a homogeneous, defined phenomenon with precise boundaries and content. The improved statistical analyses of actual female and male enrolments in school and University systems in many countries which we have seen in the decade 1975-1985, both world wide and in different cultures, has illustrated, however, that diagnosis needs to be focussed on specific and different disciplines and subdisciplines: chemistry as distinct from physics, biochemistry as distinct from chemistry, chemical engineering as distinct from civil or electrical engineering, for example. The most researched discipline has been engineering and this has the most sharply highlighted differences between subdisciplines. Some schoolbased work does usefully separate out physics from chemistry and biology in the fieldwork; but does not adequately distinguish the *interpretive* results by discipline. Policy work in particular continues to generalise about "women in science and technology" in unacceptably broad generalisations.

Yet increasing statistical evidence from the international organisations (Byrne, 1989) and an earlier analysis of a wide range of work of women and engineering (Byrne, 1985) convinced the writer that there were highly different patterns of behaviour operating both at student (girl, boy) level and at staff levels, in different disciplines and subdisciplines. It seemed evident that future research should focus increasingly on teasing out the different female enrolment and progression patterns in different disciplines and subdisciplines. The corollary of this was that explanations of these increasingly diversified results were as likely to lie in the institution-based factors (the institutional ecology) and in the nature, structure and ecology of each discipline itself (the ecological niche), as in the girls and women themselves.

Accordingly, the UQ WISTA research has been based on a survey of where women actually are, and are not, in a wide range of scientific and technological disciplines across ten higher education institutions and across two full academic years. The methodology is set out in Chapter 2, and the results are incorporated into later Chapters.

From role modelling to mentorship

This discipline-based detailed analysis has, firstly, been used to question the widely-prevalent and yet quite unfounded belief in role modelling as a *single policy mechanism.*

The shift away from role model theory as a policy mechanism to more overt and conscious use of mentorship is set out in full in two later Chapters. It is a further example of a paradigm shift from blaming *women* ("if only we had more women role models, we'd have more women engineers") to making *men* (who are still over 90 per cent of the leadership and of the power structure) responsible for positive action to lift women over attitudinal and other barriers. But the UQ WISTA research not only moved from the blaming-the-victim approach of re-examining women to looking at those who caused the problems or controlled the processes and the educational environment. It was a conscious shift to what Hess and Ferrée described as "pushing the field beyond the simple add-women-and-stir approach for incorporating women into existing paradigms of research" (Hess and Ferrée, 1987, p.9).

In addition to moving to paradigm shifts, we have also reset or clarified some **concepts** which we see as fundamental to reaching a more holistic approach to women's status in science and technology. These are the concept of critical mass; the concepts of nontraditionality or sexneutrality; and the image of science.

THE CONCEPT OF CRITICAL MASS

The concept of critical mass is fundamental both to the aspects of institutional ecology investigated, and to a proper understanding of the influence of some (but not all) of the factors of influence. When a particular group (girls, the working class, ethnically different subgroups) is a **minority** of a school or college class of students, or a minority in the educational institution as a whole, it is below the **threshold** of proportion of the whole which would enable the groups of girls (etc) to be seen as a balanced and integral part of the class or institution. The minority group is not seen as "**normal**" recruitment. Critical mass in this context is therefore the proportion which forms the threshold beyond which a minority group needs to move, in order to establish (a) a sense of normality, a transcendence of identity beyond "the rubric of exceptions", and (b) sufficient support to the minority group for its members to continue, not to drop out, and to achieve without constraint.

In the context of policy formation and implementation, Alma Lantz describes this as a process under which "once a certain proportion or number (mass) of a population is present, recruitment and retention of that population becomes a self-sustaining and self-perpetuating system" (Lantz, 1982). Critical mass theory asserts that organic, longterm and sustained change will only occur in institutions, Departments or other "populations", **above a threshold point**. This threshold is the point at which a minority group becomes a large enough proportion of the whole, to become a "critical mass", that is, a mass of significance. The theory is one of level of influence, of identity, of potency as a change agent, and not one of numbers as such. The threshold for change (even if the change is still from the perceived abnormal to the perceived normal) may well vary from scheme to scheme, issue to issue. Lantz postulated that for success (ie self-sustaining and self-perpetuating change), the effect of the passing over a threshold into normality (away from untypicality) had to be **evident**, or felt in the relevant community.

Critical mass is one of the *dimensions* which form part of the fundamental matrix of our theoretical framework, and the concept will recur throughout this research report.

When we re-examined the current theory, it seemed evident that it was highly relevant to the much-reported issues of male and female attribution of different disciplines as normal for males or for females, abnormal for either sex, or as sexneutral. Fairly obviously, there would be a threshold above and below which a minority would be seen as (and would feel) normal or untypical respectively. One question we addressed was whether different levels of critical mass were likely to produce significantly different behaviour patterns in girls who were a very small minority (say 5 per cent); and girls who had achieved a critical mass over a threshold (to be defined) into alleged sexnormality or sexneutrality in terms of their peers' and teachers' perceptions of them. We re-examined the whole concept in relation to the now substantial research literature on the sex-differentiated attitudes of school students to science and the sex-differentiated behaviour of school students in science classes.

We have concluded that, in terms of enrolment proportions,

* There is a **critical threshold** in the proportion of female enrolment of the whole class or institution.

* **Above** this threshold, when women achieve critical mass, their enrolments are seen as **normal**.

* **Above** this critical mass threshold, female enrolments continue to be substantial **without affirmative action**.

* **Below** the critical mass threshold, female enrolments are still seen and imaged as untypical, **abnormal** or exceptional.

* **Below** the critical mass threshold, female enrolments do not increase above 5 per cent or 10 per cent **unless** there is **constant affirmative action**.

There are obvious policy implications which flow from this.

We should record a *caveat* that it must be said that evidence is far from decisive on the issue of critical mass, although we remain convinced that critical mass theory provides a logical and valid explanation of the actual reported behaviour of minorities of different proportions in educational settings. Later work by Lantz (1985 pp.347-354) reviewed work on the possible influence of the male-female ratio in the classroom in the context of a critical review of issues concerning mathematics enrolments, and concluded that it remained a "fuzzy empirical issue (producing) ... scanty evidence on the effect of the male-female ratio on attrition or achievement". A little surprisingly, Lantz questioned whether "the male-female ratio of the classroom nor the sex of the instructor is important" (p.354), although her own review recorded as many researchers who believed their work did support hypotheses that critical mass affects attrition and performance, as those who held the reverse.

Hawley some four decades ago argued that human ecology was basically a "population" problem, and that the ways in which a particular developing community (eg area or institution) was affected by the size, composition and rate of growth or decline of the population, were central to human ecological analysis. Insofar as he saw as equally central "the relative numbers in the various functions composing the communal structure, together with the factors which make for change in the existing equilibrium and the ways in which such change occurs", he foreshadowed some of the elements of what we now call critical mass theory (Hawley, 1944).

Overall, we take the view that the balance of the research evidence across a cluster of issues, supports critical mass theory. Where the UQ WISTA research departs from previous stances, is in ***the policy implications*** of critical mass theory. The hypothesis that women are intimidated (deprived of equal discourse, receive less teacher attention) if they are less than a secure proportion of a mixed class, has been used, for example, to support policies for the provision of single-sex learning environments for girls in maths and science. We will argue in a later Chapter that this is to misinterpret available evidence and theory: the real implication should be to change the character of the male-dominated "coeducational" learning environments in which girls are effectively in a boys' class and not a sexneutral one.

A feminist approach

The UQ WISTA study incorporates some, but by no means all, feminist theory. This does not mean that we in any way suspend rigorous standards of scholarship. *Feminism* is a seriously misunderstood word in Australia, and a much misused one. This is not the place to elaborate on the complexity of the range of feminist concepts (Radical Feminism, Marxist feminism, liberal feminism and all the other labels stitched on by academics). But just as, although there are many *branches* of psychology or sociology, but a core of elements, processes and approaches which distinguish these disciplines from each other and from other disciplines, so there are some core elements and approaches which define feminism as such.

Feminism does ***not***, contrary to the popular media, mean "women taking over as men" or "anything to do with women", or "all women and all men are exactly the same". Feminism is a different way of looking at the world of human behaviour and of human power and organisation, a world which has been constructed and controlled historically by men. All branches of true feminism have in common the following:

- ***A rejection of biological determinism.*** Feminism is based on the knowledge (not assumption) that all human gifts and abilities are equally distributed between men and women, across the sexes and between the sexes. Feminism rejects the premise that men (all men) are innately different from women (all women) in all respects, or that we are "equal but different" or "complementary".

- ***A clear differentiation of concepts of "male and female" (sex), from concepts of "masculinity and femininity" (gender).*** Maleness and femaleness are limited to a very few characteristics *universal* to each sex and *exclusive* to that sex (reproductive systems, male wrist strength, innate aggression). Other sex differences, even physiological ones, are found at the majority/minority level only (usually about two-thirds to one-third). Two-thirds of men are heavier and taller than most women; but some women are taller and heavier than some men. Therefore there is an overlap between the sexes and society/government ***can't*** say "women can't handle heavy work" or "men can't nurture young children" without denying the actual capabilities and gifts of one-third or so of each sex. Masculinity and femininity are, by contrast, ***socially-constructed*** gender or sex roles, and are what society thinks "normal" men and women should do. And what is socially constructed, can be socially deconstructed!

- Notwithstanding, feminism recognises and accepts that all societies have in practice been constructed as sex-role-differentiated against perceived "norms" of social behaviour, and that therefore ***most*** women will have come to adulthood through a child-rearing pattern and school experience which has produced a different (socially-conditioned) life-experience and set of attitudes, values and perspectives, from that of ***most*** men. Most, not all.

- All feminism is based on the belief that this artificial sexrole differentiation produces systemic and deep-rooted inequality for women; policy-oriented branches of feminism recognise that socially-constructed imposed gender-roles can also disadvantage men.

- And finally, all feminism argues that the "women's perspective" which results from this social conditioning on the way to adulthood, needs to be better heard in policymaking, and used to greater effect in all realms of life; not least in reconstructing and developing social welfare.

It is in the context of these first premises, that we have also reviewed the concept of "nontraditionality".

NONTRADITIONAL, SEXNORMAL, SEXNEUTRAL? A POLICY ISSUE

For a further conceptual muddle has emerged in relation to sexrole theory and whether or not girls and boys are differently "programmed" biologically, or are merely conditioned from birth.

Earlier general research on gender and education has highlighted the relationship of adolescent motivation and vocational aspirations in young adults on the one hand, and the perception of subjects, disciplines or areas of knowledge as "male" or "female" on the other. Other studies contrast disciplines as nontraditional or traditional for the sex concerned. Definitions, however, as to what is traditional or nontraditional (or allegedly sexneutral) can vary both according to culture, according to the prevailing dominant social definition of sexroles, and according to the purpose of the definition (eg for legislation or special training schemes). This led us to see a need to define more clearly than some previous research, what is meant by nontraditionality and by "sexnormality" in choices and aspirations.

No finite international or national agreements have yet been achieved on how to define a discipline or occupation as "nontraditional" for one sex or another. Governments, agencies, institutions and employers in different countries have increasingly had to reach a contextually agreed definition in relation to antidiscrimination legislation, or to the funding of special training and employment schemes for the under-represented sex. The UQ WISTA research also needed to agree a scale of nontraditionality for interpretive purposes.

The most widely used cut-off point in the USA, Sweden and the UK has emerged as from 30-33 per cent; that is, if one sex is less than about a third of the occupation or discipline, it was designated as nontraditional for the under-represented sex. Some individual schemes have, however, varied to as low as 20 per cent and as high as 40 per cent. It is noted that in Hite's (1985) study of 481 men and women doctoral students in twenty-seven fields at a large State University in the American midwest, she classifies traditional for women as an enrolment of more than 40 per cent women and carrying a "feminine" orientation; androgynous as 20-40 per cent women enrolments; and nontraditional as less than 20 per cent female and historically "masculine" in orientation. In Hite's classification, biochemistry, veterinary microbiology and biological sciences are androgynous; and physical sciences, computer sciences, geosciences, statistics, chemistry and physics are classified as nontraditional. Somewhat startlingly, botany, however, was also classified as nontraditional (presumably American women do not enrol beyond the 20 per cent level which would not be the case in Australia) (Hite, 1985, p.10). In the specific context of UQ WISTA's examination of recruitment to higher education and the sex-attribution of disciplines and subdisciplines, the Queensland WISTA team started by taking ***30 per cent*** as the cut-off point below which the enrolment of the under-represented sex was seen as nontraditional.

On further investigation of the research literature and the reports of many special projects (both in Australia and overseas), however, we noted some repeated patterns in the reported perceptions of either staff or students in the disciplines in which they worked or studied. In studies of the sexrole attitudes of school children, of higher education students, of the experiences of minority women in the labour market, there is a consistency in reported evidence. Different kinds of research reports of pupil attitudes to opposite-sex involvement in science and technology disciplines have, in particular, identified further subdivisions within the nontraditional area to show degrees of untypicality through to perceived abnormality. The boys in the British GIST (Girls into Science and Technology) project were, for example, already labelling girls who did physics in the 11-13 years of secondary schooling as not only untypical, but "a bit peculiar" (Smail, Whyte and Kelly, 1982).

Reviewing the research literature referred to in later Chapters against these questions, we arrived at a clearer, but a subdivided, conceptual definition of sexrole perceptions. Where girls and women were a minority but still a *relatively significant* statistical group (approaching a critical mass), they have tended to be described as *untypical* and as a minority, but they have not necessarily (indeed, rarely) been described as unfeminine or as acting abnormally for their societally-ascribed sexrole.

But by contrast, where girls and women are a smaller minority, they have constantly been perceived as and described as *abnormal* rather than merely untypical. This is significant because if peer group and staff-student interaction reflects this perception, girls and women have to face not only the practical difficulties of minority status, but also an attack on the ***normality*** of their sexrole identity. Moreover, it affects both role model theory and mentorship. Typical adolescent girls will not identify with an abnormal (sexrole abnormal) role model. The character of mentorship is strongly affected by perceptions of normal or abnormal status in protegés.

There is one further subdivision within this second band. When girls and women are a very small minority indeed (one of the 3 per cent female professoriate; one of only four girls in a tertiary physics or engineering class of fifty or more; one of only eight women plumbers or electricians in a firm's workforce of a hundred), they are described **not only as sexrole abnormal, but as the rubric of exceptions**. That is, they are peripheralised and the general transferability of their experience and their achievement is denied. This is a serious policy issue. As long as a group can be written off as so exceptional as to be the constant exception to the rule, they cannot be used as a transferable basis for change.

Finally, we distinguish between **sexnormality** and **sexneutrality**. These are not the same in the labelling of disciplines and occupations. If a discipline is seen as untypical for girls to the point of sexrole abnormality, attitudinal barriers present a major hurdle to all but the very gifted, middle class and/or confident. If the discipline is seen as nontraditional in numbers but sexnormal, in behavioural and identity terms, there will still be some attitudinal barriers, but there is likely to be more encouragement from relevant adults for girls to overcome these. If the discipline is seen, however, as sexneutral, it will have been presented as normal for both sexes from the start, and attitudinal barriers will not have occurred, especially in progression (as distinct from access).

For example, physics is regarded by adolescents as sexnormal for boys but nontraditional (and sexabnormal) for girls, while the complete reverse applies to biology. Neither can therefore be regarded as sexneutral. By contrast, the perception of English (or the language of origin) is that it is essential and normal for both sexes, and both enrol in almost equal number in the main secondary years. It is possible to see this subject as sexneutral. But mathematics, which ranks equally as a mainstream core foundation subject in secondary education, acquires an early sexnormal label for boys, and thus a "male" attribution and an untypical label for girls. It is not, therefore, seen as sexneutral.

For the purpose of analysis in the UQ WISTA research, a scale of nontraditionality has been created. The actual statistical percentages may be negotiable (upwards), but the important issue is the concept of different **thresholds** of untypicality. This should be related to the definition of critical mass, to image (how "male" is a subject?), to adolescent curricular choice (how does it affect normal sexrole identity, critical at that age?), and to role modelling (is the role model seen as sexnormal, abnormal or so exceptional as to be irrelevant?). The following scale has been used as a frame of reference throughout the UQ WISTA research

THE BYRNE SCALE OF NONTRADITIONALITY

Recruitment of both sexes above 30 per cent of enrolments (eg 70:30 or 60:40 etc)	Students and teachers see as sexnormal for both sexes and therefore the discipline is seen as **sexneutral.**
Recruitment of either sex of 16-29 per cent of total	Seen as **sexnormal** for the major sex and **untypical** but sexnormal for the minority sex.
Recruitment of either sex from 9-15 per cent of total	Seen as **sexnormal** for the major sex and **abnormal** for the minority sex.
Recruitment of either sex at 8 per cent or less of total	Seen as **sexnormal** for the majority sex and **both abnormal and "the rubric of exceptions"** for the minority sex. That is, they don't count as in any way representative or as transferable models.

The scale is designed as a conceptual and interpretive one and not as a tool of precise empirical measurement, and will be used later as a framework against which to interpret our statistical analysis. [Table 1(i) illustrates.]

SCIENCE AND TECHNOLOGY: DEFINITION, AND CHARACTERISTICS AND SELECTION OF DISCIPLINES

At the conceptual level, it became necessary to look at a number of ways in which science and technology have been defined, challenged or reexamined. It was also relevant to define precisely what we meant by science and technology respectively (not necessarily the same thing) in the specific context of the WISTA Policy Review project.

We did not accept the apparent and (to us, artificial) distinctions drawn by many writers between science and technology.

Science is itself a concept, not a clearly definable phenomenon as such. At one end of the scale, of course, **scientia** originally simply meant knowledge, and as late as 1903, the Shorter Oxford English Dictionary gave one definition as the philosophy and logic included in the Oxford Literae Humaniores. But as early as 1725 the concept of scientific rigour as we now understand it, meant "study concerned with a connected body of demonstrated truths or with observed facts systematically classified and more or less colligated by being brought under general laws, and which includes trustworthy methods for the discovery of new truth

TABLE 1(i)

SURVEY DISCIPLINES : ANALYSIS OF 1985 FEMALE UNDERGRADUATE ENROLMENTS

Designation of disciplines on BYRNE Four Point Code of Sexnormality and Nontraditionality

Code:

Female enrolment of		
30% plus	**sexnormal** for women	(1)
29% - 16%	**untypical** for women	(2)
15% - 9%	**abnormal** for women	(3)
8% and below	**rubric of exceptions** for women	(4)

0 = not offered at undergraduate level in this institution

Institution	Physics	Chemistry	Mathematics	Computer Sc.	Biochem.	Microbiology	Genetics	Biotechnology
UNSW	2	1	1	1	1	1	0	1
NSWIT	3	1	1	2	0	0	0	1
U of Q	2	1	2	2	1	1	0	0
QIT	2	1	1	3	0	0	0	1
MONASH	2	1	1	1	1	1	1	0
RMIT	3	1	1	2	0	0	0	1
ADELAIDE	2	1	1	2	1	1	1	0
SAIT	3	1	0	2	0	0	0	0
UWA	2	1	1	2	1	1	0	0
WAIT	3	1	2	0	0	0	0	1

TABLE

SURVEY DISCIPLINES : ANALYSIS OF 1985 FEMALE UNDERGRADUATE ENROLMENTS

Designation of disciplines on BYRNE Four Point Code of Sexnormality and Nontraditionality

Code:	Female enrolment of		
	30% plus	**sexnormal** for women	(1)
	29% - 16%	**untypical** for women	(2)
	15% - 9%	**abnormal** for women	(3)
	8% and below	**rubric of exceptions** for women	(4)

0 = not offered at undergraduate level in this institution

Institution	Civil Eng.	Chemical Eng.	Ceramic Eng.	Electrical Eng.	Mechanical Eng.	Minerals	Geology
UNSW	4	2	3	4	4	4	0
NSWIT	4	0	0	4	4	0	3
U of Q	3	3	0	4	4	4	2
QIT	4	0	0	4	4	0	4
MONASH	3	2	0	4	3	0	2
RMIT	4	3	0	4	4	4	3
ADELAIDE	4	2	0	4	4	0	2
SAIT	4	0	0	4	4	4	3
UWA	4	0	0	4	4	0	2
WAIT	4	4	0	4	4	4	3

within its own domain" (SOED, 1978). This is also a still defensible generic definition, which allows a more general interpretation of the scientific approach than the previous century's location of scientific within the area of demonstrated proof rather than demonstrated truth: "of a syllogism, a proof; producing knowledge, demonstrative" [(1667) SOED, 1978].

If one view of science lies in the arena of **demonstrated truths**, of proofs, of knowledge tested by process, an alternative view is as a means of **understanding** the world by deepening knowledge of it. This antithesis is important in relation to female and male motivation for choosing to study science as is the antithesis of the perception of science as objective and finite, and the converse view that it is value-loaded and negotiable. Albury and Schwartz, for example, hold that "the scientific method, if such a thing exists at all, is not a universal process for arriving at the truth, but a way of deepening the knowledge available within a particular framework for looking at the world" (Albury and Schwartz, 1982, p.78). Robin Clarke defines science as "a means of constructing models of reality", and "alone claiming unique access to an objective understanding of the world". He sees as encouraging, the move away from reductionism (viewing reality by examining its constituents in smaller and smaller particles) towards more holistic thinking. Studies of interrelationships thus become an increasingly important part of scientific activity. Clarke also sees science as "if ... no longer to be trusted as the sole arbiter of truth, it remains an immensely powerful - and probably the most powerful - "**means of imaging the world**" (Clarke, 1985, p.7).

Feminists would argue that a scientific world which is only informed by the knowledge and "construction of reality" of the male experience of life is incomplete and flawed. Yet we also know from research that both girls and androgynous boys are put off by subjects that are presented as not set in a **social** context, are not people-oriented and not people-friendly. Technology in particular is often (wrongly) presented as user-unfriendly.

To the extent that Robin Clarke argues that historically "all of the societies which have ever existed on this planet have possessed a technology: very few of them indeed have possessed a science", he appears to accept the somewhat false or artificial antithesis that science is curiosity-driven knowledge and that technology is the application of invention. He argues that traditional or indigenous technologies are not, in fact, produced only as a result of scientific research. Innovations from steam engines to zip fasteners were more often the result of individual ingenuity than of science-based laboratory work. Clarke differentiates between technology arising out of innovation and inventiveness, and "science based technology" which tends to produce social impacts of greater magnitude; nuclear weapons, electronics, data processing. Arnold Pacey, in turn, recognises a general public assumption when he discusses the culture-base of technology; that technology is seen to be about "machines, techniques, knowledge and the essential activity of making things work". He goes on to distinguish technology-practice from "technique" (in Jacques Ellul's sense) as "the application of scientific and other knowledge to practical tasks by ordered systems that involve people and organisations, living things and machines" (Pacey, 1983).

Technology has traditionally been seen as the applied arm of science, the particular rather than the theoretical or conceptual: "the scientific study of the practical or industrial arts (1859)" (Shorter Oxford English Dictionary, 1978), or latterly "the practice of any or all of the applied sciences that have practical value and/or industrial use" (Chambers Twentieth Century Dictionary). By the mid 1960s in Britain, technology in education was seen as "the purposeful application of man's (sic) knowledge of materials, sources of energy and natural phenomena" (Schools Council, 1968). Nearly twenty years later, the UK Schools Inspectorate identified technological (as distinct from scientific) work as involving the application of scientific ideas to production; improving design and efficiency of devices or systems; using these to tackle a scientific discipline; applying scientific principles to modify a product by problem-solving; using scientific knowledge to make balanced and informed judgements about technological innovation (Department of Education and Science, 1985[b]).

While science is related in the ordinary mind with principles, rigour, objective truth and abstract enquiry, technology usually carries a public image of association with machines, systems, or even what Jacques Ellul called "la technique". By this, Ellul meant far more than machine technology, or principles of advanced mechanics applied to systems, but rather any complex of standardised means for attaining a desired technocratic result and a predetermined result. Ellul argued that "in the modern world, the most dangerous form of determinism is the technological phenomenon. It is not a question of getting rid of it, but by an act of freedom, transcending it" (Ellul, 1954). J.K. Galbraith defined technology as "the systematic application of scientific or other organised knowledge to practical tasks" and as an activity involving complex organisations. He also saw technology as in no way value free, but as heavily value-laden (Galbraith, 1972).

In Australia, a recent definition by the Australian Education Council located technology clearly in the power area of production rather than in the power of ideas circuit of society: "Technology implies much more than the tools and technical inventions of a society. It involves the whole complex of skills, techniques and processes by which a group maintains production and applies knowledge" (AEC, 1985). The AEC's view of technology as an instrument of industrial power reflects views characteristic of many writers on the role and status of science today.

In practice, much of what is described as technology is rooted in sound scientific theory, and much of what is described in University Handbooks as applied science, would in fact, match these definitions of technology. They overlap; they intermesh. More relevant to the UQ WISTA research, was the pure/applied antithesis.

Pure or Applied? The Applied Filter

For reasons not yet clear, and again discussed further in later Chapters, the statistical evidence shows consistently that women enrol more easily, frequently and in greater numbers in science and maths studies that they see as pure, creative, free floating, than in those whose image and content is "applied". Here, we note one extra filter which technology (as distinct from science), represents: women are proportionately filtered out more significantly from subjects and disciplines described as technological or located in Faculties of Applied Science and Technology. The UQ WISTA data confirms this trend.

The Image of Science: A Critical Filter

How we define and see science and technology has begun to emerge as causally related to the issue of gender and science. Writers ranging from Kuhn to modern feminist academics have challenged past received wisdom about the nature, construct, characteristics of science as such. The **image** of science and technology proves both to be inaccurate and to be a critical filter; a filter not only to most girls, but also to the androgynous boys of whom fewer enrol in science and technology in each generation. In reviewing the research and philosophical writing about science, several aspects of **image** emerged. Science has been traditionally (wrongly) portrayed as:

- objective, factual and non-negotiable
- dealing with phenomena and not people
- culture free and value free
- male, masculine and exclusive
- harder than other areas of study.

We set out with hypotheses that any or all of these images of science and technology, or of different branches and disciplines, was likely to be a negative image for more girls than boys.

Science is not Value-Free

We hypothesised, from an earlier literature review, that the "objective value-free" image of science discouraged girls.

The general perception of science has been as an intellectual, principle-based area of curiosity leading to knowledge, but located in an abstract attempt to explain the world by systematic, objective, ordered analysis. The perception of technology emerges as the applied arm, working principally through production and systems. In neither case can the "objective" label be fully sustained in the sense of so designing experiments that there is no vested interest in the outcome. Researchers do not come to research with a **tabula rasa**; results are often presented in a retrospectively constructed rationality or are the result of prejudged expectation. Stephen Jay Gould, for example, cites the hundred year old research of Paul Broca, a French brain surgeon who measured brain weights of 292 men and 140 women taken from autopsies at four Parisian hospitals in the early 1860s. Broca found that the female brains averaged 14 per cent lighter than the male, and the conclusions drawn from this and his published results became a rallying point for the belief in men's alleged cognitive and intellectual supremacy for fifty years. Only when Stephen Jay Gould re-examined the implications of the data 120 years later, was it discovered that the brain weight difference was not due to sex as such, but to differences in age and height and to a prevalent degenerative brain disease more common in women than men at the time. Broca had seen no need to cross check his results against other factors than the first level weight difference, since they confirmed the prevailing received wisdom of the time (and his own personal belief) that women were inferior and that there was a straight biological reason for this. His work helped to hinder the secondary and higher education of women for fifty years, in bolstering the alleged biological justification for their exclusion from advanced intellectual study. Albury and Schwartz, in a review of scientific research and policy, cite other examples of science or technology which were heavily influenced by strong value-based or ideological stances and which masqueraded as "objective" science (Albury and Schwartz, 1982).

Technology is no more value free than science. The traditional view that "technology is essentially amoral, a thing apart from its values, an instrument which can be used for good or ill" (Buchanan, 1965) was as characteristic of its period as the equally limited educational view of technology as only applied to systems or products, which was then prevalent. Two decades later, Pacey distinguishes those aspects of technology which, like basic science, have a transferable theoretical core, and those which are heavily contextual or culturally-based by the country or sector in which they are practiced.

> "So is technology culturally neutral? If we look at the construction of a basic machine and its working principles, the answer seems to be yes. But if we look at the web of human activities surrounding the machine, which includes its practical uses, its role as a status symbol, the supply of fuel and spare parts, and the skills of its owners, the answer is clearly no. Looked at in this second way, technology is seen as part of life, not something that can be kept in a separate compartment". (Pacey, 1983, p.3).

Why does this matter? Firstly, because of bias where researchers do not concede (or are not aware of) their value bases; and secondly, because there is considerable research evidence that more girls than boys reject the physical sciences and technological disciplines when they are imaged or marketed as value-free and abstract.

Science: Masculine, Feminine or Gender-Neutral?

In terms of the issues raised in discussing nontraditionality, perceived sexnormality or sexneutrality of disciplines, the masculine image of most scientific and technological disciplines emerges as a major factor in research studies, cross-nationally and cross-culturally. There are three issues:

- The perception of science as a male area by adolescents and young adults making curriculum and discipline choices (which filters young females out from an unconditioned choice).
- The actual male-dominance of science and technology in terms of participation of teachers, learners and producers (which creates an ecological niche supportive to males and not to females and raises issues of critical mass).
- The construction and design of science in disciplines on a paradigm seen as male, patriarchal and instrumental (which is described by some as creating an inappropriate teaching:learning environment not only for females, but also for many males).

Bowling and Martin (1985) identify three overlapping influences of patriarchy on scientific knowledge: "the choice of topics for study, the content of scientific theories, and the boundary between science and nonscience". One might note at this stage one or two aspects relevant to higher education. For example, a committee set up jointly by the Royal Society and the Institute of Physics in London to look at physics education gave particular emphasis to what they called "the masculine image of science" which, the report stressed, had two effects. It was likely to lead parents and teachers to see scientific studies as inappropriate for girls; and girls themselves as likely to see achievement in science as incompatible with femininity (Easlea, 1986).

There is more subsumed within the attitudinal question than is immediately apparent, however. It is more complex than the more easily measurable questions of boys' territoriality, sex-appropriate labelling and peer pressure or self-esteem. A deeper problem is what Evelyn Fox Keller calls "masculinist distortions of the scientific enterprise" which she sees as creating a potential dilemma for scientists who are also women and who have acquired the alternative perspective on the world which feminist analysis produces (Keller, 1982). Debates about masculine bias or perspective have centred on very different issues. Some argue that the predominance of men in the sciences has led to a bias in the **choice** of which problems scientists have chosen to investigate, and which they have left totally unresearched; and how the problem is defined. It is, for example, no accident that ***real*** research dealing with the menopause and other aspects of health idiosyncratic to women, is a very recent phenomenon; real research as distinct from the psychiatrically-derived "evidence" used by male specialists to write off medical physiological symptoms as caused by female neuroses.

Others argue that the actual **design** of empirical science is male-biased. Keller is prominent among those who see the actual design of research as male-biased, citing among her examples that almost all animal learning research on rats has used only male rats (that is, male equals the normal prototype). One might also note that the English Crowther Report 15-18 which was so influential in the redesign of upper secondary education in the 1960s, was based on major commissioned research limited to a sample of young male National Servicemen: no young females. Similarly, Bernstein's work on elaborated and basic codes in language was first based on a sample of young males only.

Pacey's reassessment of technology as needing to bridge what Fee calls "the previous separation of human experience into mutually contradictory realms" (ie science and nonscience), argues that:

> "a profound contribution that could be made toward creativity in science and technology would be to encourage the involvement of women in this field at all levels. Not, I must add, as imitation men, copying all the absurdness of men, but to challenge and counteract the male values built in to technology". (Pacey, 1983, p.107).

Elizabeth Fee suggests that "the sciences have been seen as masculine, not simply because the vast majority of scientists have historically been men, but also the very characteristics of science are perceived and seen as sex-linked" (Fee, 1981, p.86). That is, the alleged objectivity we spoke of earlier (rational, authoritative, logical, impersonal, hard and cold) is ascribed by a kind of circularity as characteristic of masculine traits, and then endorsed as scientific. The "female" antithesis is seen as subjective, irrational, intuitive and deductive, warm and soft, widely ascribed as normally female (Zillborg, 1974; Gelb, 1974). Structurally within the sciences, this has been institutionalised within the hierarchy of the sciences - "the 'hard' sciences at the top are seen as more male than the 'soft' sciences at the bottom" (Fee, 1981, p.86). Fee sees science not only as essentially part of the power structure of social democracy, and no longer as an academically detached intellectual area. She also sees it as part of a male-dominated power structure. "The production of scientific knowledge is highly organised and closely integrated with the structures of political and economic power" (Fee, 1981).

Science and Social Responsibility

A further issue is the relatively newly researched image and attribution of science and technology as socially responsible and people-oriented on the one hand or irresponsible, uncaring and instrumental on the other. Although the social responsibility question is wider and more complex than we can fully treat in this research, it is relevant because of perceptions in the research literature that one factor which filters girls out at the stage of adolescent choices of subjects and careers, is their perception of science as socially irresponsible, non-caring and destructive. To this, we have added the hypothesis that higher education scientific teaching also substantially excludes issues of social responsibility. We deal with this in more detail in a later Chapter.

Lowe and Worboys (1980) discuss the ideological base of the development of popular ecology as a criticism of modern science in a seminal critical review, and conclude that "the environmental crisis highlights a crisis of confidence within science and a crisis of science's authority in society". They see, ironically, a constant appeal to ecology as a reinstatement of the prestige of science and a "reaffirmation of its role as an authoritative and integrating social institution" (Lowe and Worboys, 1982, p.446).

Social control as an ethical technological issue is not, of course, new. Closer examination of the characteristics of technology has led many researchers and thinkers to attempt to discover the laws which govern it. One of two laws postulated by Jacques Ellul in the 1950s was that "technical progress today is no longer conditioned by anything other than its own calculus of efficiency". This bleak view is so relevant today that the socially-irresponsible, socially-unconscious image of many technological and scientific disciplines is widely held to be significantly influential in switching girls (and possibly androgynous boys) off science. One of the central issues investigated in the WISTA project is the extent to which the current image of the technological disciplines in fact does precisely fail to appeal to girls who see them as in no way akin to Pacey's culturally relevant location in "a web of human activities", a point which the Deans and Heads of engineering made constantly to us in the group interview sessions in the institutions.

> **The WISTA research therefore reviews the two core factors of the interrelationship of attitudes (both male and female) and image.**

The researcher shares Elizabeth Fee's view that "we need not suppose that even the most determined critique of currently existing science or proposals for alternative forms and visions of scientific investigation necessarily imply a rejection of either rationality or progress". To challenge the existing value structure and dominant ideology of the scientific world does not necessarily imply any loss of rigour or method in the process. It still means using techniques for what Mouly called "the process of arriving at dependable solutions to problems through the planned and systematic collection and analysis of data", which may differ from the traditional even although they are systematic (Mouly, 1978).

Similarly, we are (of course) familiar with the perceived relevance of the dual work:motherhood and work:wife role, and the problems of child care. The personal reasons of young women in higher education for dropping out include, for example, financial hardship, pregnancy and domestic responsibility (when male students marry, they acquire domestic *infrastructure;* when women students marry, they acquire domestic *responsibility*). Other reasons include peer group pressure in nontraditional subjects or inadequate mathematics. The possession of an articulate, well educated working mother who is a successful scientist, may well have the possible effect of inspiring a daughter by the role-modelling process.

But these issues are either not remediable within the tertiary education system, or they are already being quite adequately researched and developed elsewhere. It is not lack of public understanding of the issue which hinders women who have a dual role and no child care, but the lack of public and political *commitment* to deal with the need for such infrastructure. And what hinders progress in schooling is less the lack of understanding of sexstereotyping in classrooms, given two decades of research in the area, than the lack of will on the part of educational authorities, principals and teachers to admit that it happens at all in their schools, or to allocate resources to deal with the problem.

While therefore the researchers recognise that many social factors external to education and aspects caused by other sectors of education are relevant, they do not explain adequately why *despite* lack of child care or sextyped careers advice or inappropriate maths school teaching or male peer hostility to girls choosing science in adolescence, many girls *do* succeed in access to and progression in science and technology in higher education.

For these reasons, the research has focussed on *higher education* institutions, and not only on the critical filter effects of a sex-role stereotyped secondary schooling. The widespread tendency for the Universities and Institutes to argue that there is nothing that they can do further to influence the entry of women to science and technology in higher education, because both research and policy effort should be devoted instead to the schooling system, is an inadequate alibi. We do not accept this oversimple approach.

Firstly, if it were true that all of the influences were unalterably set by the schooling and early social conditioning processes, this would not explain why more girls apply to enter one higher education institution than another; why one University keeps or recruits twice as many women postgraduates in a given discipline than others; or why the female recruitment to the same disciplines in different institutions can vary from double to half the average. Secondly, we hypothesised that higher education institutions, particularly in the first undergraduate year, are at least partially responsible for the *non-progression* of women after first year undergraduate studies.

Scope and Limitations

The focus throughout the project has been on issues which are seen as either caused by, or are able to be remediated or counteracted by, the educators and by educational institutions in terms of educational policymaking.

The principal researcher recognises, of course, that the causes of women's underachievement, lack of progression or concentration in areas of education, training and work socially ascribed as female, are not solely a result of the influence of the ten factors we have used as our focus. The behaviour of girls and boys in adolescence, for example, has its early roots in primary education. Children also come in to school at four or five years old with sex-stereotypic attitudes already preset, with a strongly developed sense of what is differentially suitable for boys and for girls - separately and with mutual exclusivity. And indeed, almost the first comment made by Heads and Deans of Schools in our group interviews, in almost all meetings, has been "But the problems are made in the schools: they come to us (or not) with attitudes already set". Many higher education staff consistently rejected responsibility for female lack of progression on the (to us, specious) grounds that the "schools had got it all wrong" and that therefore this was irremediable.

Many of the influences which shape the career destination of women interested in science and technology occur in the first year or two in the University or Institute, and this research is premised on the given assumption that changes in the structural and attitudinal environment of tertiary institutions can still *remediate* very quickly (or of course reinforce), the sex-role stereotyping of the school and guidance systems. New tertiary policies have been seen to achieve rapid changes in a number of overseas countries. Aldrich and Hall (1980), for example, report on a wide variety of successful intervention programmes which set out to remediate at the tertiary level, problems relating to competence in or lack of maths, to inadequate science experience, to attitudes or to poor careers advice. Initiatives specifically aimed at opening up engineering to women in higher education are well established in France, the United Kingdom, the USA and in Scandinavia to *remediate* inadequate female scientific and mathematical education in schooling (Byrne, 1985). Broader initiatives to open up nontraditional work in technology and at technician levels in areas like mining and telecommunications have again successfully remediated inadequate and sextyped schooling in Sweden, FR Germany and the USA (Byrne, 1980).

Thus, it is argued that the exclusion of *socially-caused* factors from the research does not hinder its usefulness in reconceptualising and reexamining the *educationally-caused* factors. Whether these are wholly located in schooling, or partly in schooling and in tertiary education, **higher education institutions have a proper and responsible role to play both in influencing schooling and in remediating its inadequacies.**

This report deals with the major findings of the UQ WISTA research. Separate policy monographs will deal with the discrete and major areas of maths as a critical filter and the single-sex-coeducation controversy. A further research project with three year ARC funding is now looking at the interaction of career education and guidance, prerequisites and curricular choice (the SHEP-APIST Project).

The following Chapter deals in more detail with the framework and methodology of the research.

REFERENCES

ACOTAFE (1974) TAFE in Australia: report on needs in technical and further education, Australian Government Publishing Service (AGPS), Canberra (Kangan Report).

Albury, David and Schwartz, Joseph (1982) Partial Progress: The Politics of Science and Technology, Pluto Press, London, p.11, p.78, p.89.

Aldrich, M. and Hall, P. et al (1980) Programmes in Science, Maths and Engineering for Women in the USA 1966-1978, AAAS and Office of Opportunities in Science, Washington, DC.

Australian Education Council (1985) Education and Technology, AEC, Melbourne.

Bowling, Jill and Martin, Brian (1985) "Science: A Masculine Disorder" in Science and Public Policy, Vol.12, No.6, Dec 1985, pp.308-316.

Byrne, Eileen M. (1978) Equality of Education and Training for Girls, Commission of the European Communities, Brussels.

Byrne, Eileen M. (1980) Men's Work, Women's Work? New Perspectives for Change, UNESCO, Ed/80/CONF.708/3, Paris, 14.8.80.

Byrne, Eileen M. (1985) Women and Engineering: A Comparative Overview of New Initiatives, Bureau of Labour Market Research, AGPS, Canberra.

Byrne, Eileen M. (1989) "Grounded Theory and the Snark Syndrome: The Role of the International Organisations in Research in Gender in Education" in Evaluation and Research in Education, No.3, Vol.3.

Cass, Bettina et al (1983) Why so few? Women Academics in Australian Universities, Sydney University Press, Sydney.

Cercle des Femmes Ingénieurs (1978) Ingénieur au Feminin, Cahiers CEFI, Paris.

Clarke, Robin (1985) Science and Technology in World Development, Oxford University Press/UNESCO, Oxford and New York, page 7.

Commonwealth Schools Commission (1984) Girls and Tomorrow: The Challenge for our Schools, AGPS, Canberra.

Commonwealth Schools Commission (1987) The National Policy for the Education of Girls in Australia, AGPS, Canberra.

Council for Scientific Policy (1968) Enquiry into the Flow of Candidates in Science and Technology in Higher Education, Her Majesty's Stationery Office (HMSO), London, 1968 (The Dainton Report).

Deblé, Isabelle (1980) The School Education of Girls, UNESCO, Paris, p.92.

Department of Education and Science (1985)(a) Science 5-16: A Statement of Policy, HMSO, London.

Department of Education and Science (1985)(b) **Technology and School Science: an HMI Enquiry**, HMSO, London.

Easlea, Brian (1986) "The masculine image of science with special reference to Physics: how much does gender really matter?" in Harding, Jan (Edit) **Perspectives on Gender and Science**, Falmer Press, Sussex, p.133.

Ellul, Jacques (1954) **La Technique ou L'enjeu du siecle**, Armand Colin, Paris, translated as **The Technological Society**, Vintage Books, NY, 1964.

Fee, Elizabeth (1981) "Is feminism a threat to scientific objectivity?" in **Journal of College Science Teaching**, 11, (2), pp.84-92.

Galbraith, J.K. (1972) **The New Industrial State**, Andre Deutsch, London, Second Edition, Chapter 2.

Gelb, Lester (1974) "Masculinity and Femininity" in Miller, Jean Baker, **Psychoanalysis and Women**, Penguin, Harmondsworth.

Gould, Stephen Jay (1980) **The Panda's Thumb**, Penguin, Harmondsworth.

Hess, Beth and Ferree, Myra (1987) **Analyzing Gender: A Handbook of Social Science Research**, Sage Publications, Ca.

Hite, L.M. (1985) "Female Doctoral Students: their perceptions and concerns" in **Journal of College Student Personnel**, (26)(1), pp.18-23.

Kaminski, D.M. (1982) "Girls and Mathematics: An annotated bibliography of British work 1970-81" in **Studies in Science Education** 9 (1982), pp.81-108.

Keller, Evelyn Fox (1982) "Feminism and Science" in **SIGNS,** (7)3, Spring 1982, pp.589-602.

Lantz, Alma (1982) "Women Engineers: critical mass, social support and satisfaction" in **Engineering Education**, April 1982, pp.731-737.

Lantz, Alma (1985) "Strategies to increase Mathematics Enrolments" in Chipman, S., Brush, L. and Wilson, D. (Edits) **Women and Mathematics: Balancing the Equation**, Lawrence Erlbaum Publishers, NJ, pp.329-354.

Lowe, Philip & Worboys, Michael (1980) "Ecology and Ideology" in (Edits) Buttell, F.H. and Newby, H., **The Rural Sociology of the Advanced Societies: Critical Perspectives**, Croom Helm, London, pp.433-452.

Myers, R. (Chairman) (1980) **Technological Change in Australia**, AGPS, Canberra.

OECD (1986) **Girls and Women in Education**, OECD, Paris.

Pacey, Arnold (1983) **The Culture of Technology**, Basil Blackwell, Oxford, p.6.

Schools Council (1968) **Technology and the Schools**, Schools Council Working Paper 18, HMSO, London.

Smail, B., Whyte, Judith, and Kelly, Alison (1982) "Girls into Science and Technology: the first two years" in **Social Science Review**, June 1982, pp.620-630.

Wallis, Eileen (1972) **A Most Rare Vision**, Otago High School Board of Governors, NZ, p.33.

Williams, Bruce (Chairman) **Education, Training and Employment**, Report of the Committee of Enquiry into Education and Training, AGPS, Canberra.

Zillborg, G. (1974) "Masculine and Feminine" in Miller, Jean Baker, **Psychoanalysis and Women**, Penguin, Harmondsworth.

CHAPTER II

METHODOLOGY: A HOLISTIC AND POLICY APPROACH

> ***"Not only is there but one way of doing things rightly, but there is only one way of seeing them, and that is, seeing the whole of them."***
>
> John Ruskin, The Two Paths, Lecture 2

While we do not wholly subscribe to Ruskin's first point (research would die if there were but one way ...), we do accept the premise that truth, so far as this is attainable, is more likely to emerge from attempts to see the whole of a problem.

The UQ WISTA Policy Review project attempts to investigate some fundamental questions through a holistic approach rather than the single-dimensional methods characteristic of some previous research which has looked at single factors like attitudes or image or role models. A fundamental assumption on which this project is based is that there are certain sets and subsets of factors which are (positively or negatively) influential when related to each other but not in isolation. We believe that the interdependence of some issues and factors has been imperfectly understood. Thus, for example, the writer has been sceptical for some years that role-modelling alone influences actual vocational choice or is useful as a policy mechanism. We set out therefore to review this issue specifically in relation to mentorship, critical mass and the concepts of sexnormality and nontraditionality: an integrated approach.

Similarly, many published research studies of students, teachers, target groups which have been used as assertive and credible sources by researchers to prop up current received wisdom, are limited in that they are dyadic in nature. That is, their focus of enquiry has been limited to the precise interaction of two people or two factors. This is usually for reasons of feasibility or resources rather than because of the existence of a clear substantive or formal grounded theory that conclusions drawn from studies of dyadic interaction will produce widely transferable results. The UQ WISTA Policy Review research attempts to concentrate on "not a scattered series of analyses, but a systematic ordering of them into an integrated theory" (Glaser, and Strauss, 1972, p.295).

Relationships of clusters of factors are analysed specifically in the context of the production of **midrange theories** which institutions can then use to enlighten their particular situations. Several theories may be simultaneously, but selectively, true, and institutions will need to adopt those which most nearly match their particular ecology in relation to their differing disciplines.

We base our conceptualisation of midrange theory on Merton's definition "intermediate to the minor working hypotheses evolved in abundance during the day-by-day routines of research, and the all-inclusive speculations comprising a master conceptual scheme from which it is hoped to derive a very large number of empirically observed uniformities of social behaviour" (Merton, 1958). Our methods are not aimed at what Merton calls "the codification of theoretical perspectives", but rather at a systematic approach to the relationship of existing theories to each other, to produce a new model either as a basis for further enquiry, or as an immediate policy model.

Grounded Theory: Not Empirical Proof

The kinds of complex issues being investigated in the UQ WISTA Policy Review project are almost impossible to prove by detailed empirical evidence. The multiplicity of variables which affect the curriculum choices or the vocational or institutional choices of young students is such that it would be almost impossible to construct a research design for empirical "proof" which could control for the relative importance of each. Nor would the massive expense of such a cohort study be justified unless there were a very clear **policy outcome** which could be predicted.

The findings and conclusions in this report, and in subsequent reports from the UQ WISTA Policy Review project, are based rather on the use and review of what Glaser and Strauss call **"grounded theory"**, and on the discovery of substantive theory developed through analysis of qualitative data (Glaser and Strauss 1972).

> *"By the discovery of substantive theory we mean the formulation of concepts and their interrelation into a set of hypotheses for a given substantive area - such as patient care, gang behaviour or education - based on research in the area."* (Ibid, p.288)

Glaser and Strauss argue that a specific substantive theory must be formed in order to see which of existing formal theories are applicable to the research area and to further refine the substantive (integrated) theory. There is in turn, they argue, a cyclical effect in forming and reforming formal theory, but based on regular analysis of field data of some kind.

> *"Thus substantive theory becomes a strategic link in the formulation and development of formal theory based on data.* ***We have called the latter 'grounded' formal theory*** *to contrast it with formal theory based on logical speculation."* (Ibid, p.300)

The strategy used in the UQ WISTA project in deploying limited but highly specialised and experienced resources to produce more accurate substantive theory (described later in this Chapter), complies with what Nagel saw as a need for rigorous logic: "Every branch of inquiry aiming at reliable general laws concerning empirical subject matter must employ a procedure which, if it is not strictly controlled experimentation, has the essential logical functions of experiment in inquiry" (Nagel, 1961, p.453).

We have, of course, used both quantitative and qualitative research techniques. Through these we have looked at sets of different data for each discipline within each institution, across a range of different institutions; and at patterns of relationships between enrolments and progression on the one hand, and image of disciplines, location and structure of disciplines and the main ecological factors in each University or Institute, on the other, in the specific context of the social systems we see as characteristic of the institution's ecosystem.

If we were to follow a strictly logical-deductive research model, it would be necessary to check off our research approach against what Bensman and Vidich (1972) describe as "abstract, common elements necessary to any social system". The task would be to establish possible coordinate linkages between the model and the empirical world of the social system. But one of our hypotheses is that the "normal social system" itself in the world outside tertiary institutions, is already replicated in the institutions, in institutional attitudes, in power structures, in patterns of discourse and in male-domination. Institutions mirror schools and society in their male-dominated structures, images, mentor systems and so on; we are already not talking of possible linkages but of mirror-images. The linkages which interest us are within institutions, or within aspects of institutions and outside factors; not between systems. This is a difficult task, both conceptually and empirically. For example, construction of a model for examining the relationship between recorded adolescent images of different scientific disciplines, or between student and lecturer images and treatment of those disciplines in tertiary first year on the one hand, and student diversification of choice at second year (eg biochemistry, chemistry or microbiology after first year chemistry), would present considerable methodological dilemmas.

Interpretive approaches, by contrast, assume rather that human behaviour is individual, and are based on the principle that individuals' personal interpretation of their immediate world influences their behaviour. But interpretive explanations can also spring from grounded data generated from the research. Cohen and Manion (1986) also hold that interpretive theory "must make sense for those to whom it applies", and this relates more closely to the methods used in the policy review strand, described later. We have attempted, in the span of techniques used, to relate to Medawar's (1972) stance that "scientific reasoning is therefore at all levels an interaction between two episodes of thought - a dialogue between two voices, the one imaginative, and the other critical ...". The UQ WISTA project questions much inherited received wisdom by critical reexamination but uses a degree of imagination in interpretation. A conscious effort has been made to distinguish the one from the other in our writing. The phenomenological research approach (in the sense of studying direct experience taken at its face value) works in turn through the questioning of "taken for granted" assumptions of everyday life, looking beyond cultural or symbolic structures to free ourselves of preconceptions about our particular world. The UQ WISTA researchers are attracted by Medawar's perception that "science is that form of poetry ... in which reason and imagination act together synergistically" (Medawar, 1972) and we have set out to achieve this.

To the extent that some of the hypotheses derive from Medawar's "speculative adventure, an imaginative preconception of what might be true - a preconception which always and necessarily goes a little way (sometimes a long way) beyond anything we have logical authority to believe in" (Medawar, 1972, p.22), we nevertheless also follow his more rigorous second step that "the conjecture is then exposed to criticism to find out whether or not that imagined world is anything like the real one".

Hypotheses

We attach importance to the framing of at least a core of hypotheses to be tested, while recognising the need to keep an open mind for new data and evidence (and for new theory). We concur with Borg's (1963) view that "without hypotheses, historical research often becomes little more than an aimless gathering of facts", and with Kerlinger (1970) that "hypotheses are, in essence, about the relationship between variables; and they carry implications for testing these". Kerlinger however, assumed that subjective belief could be tested against objective reality. We are ambivalent about the capacity of scientific research to be "objective", and we set out so far as possible to make clear our assumptions, our givens and our research-based stance, in explaining our hypotheses. Glaser and Strauss regard it as characteristic of field work that multiple hypotheses are pursued simultaneously, and we conform to this. Clearly in this model, earlier hypotheses quickly become integrated to form the basis of a central analytical framework which rapidly crystallises. One of the processes in moving from these initial deductions to important new concepts, basic classification categories or to significant new hypotheses, is, however, for the researchers to use replacement (or alternatively, endorsed) hypotheses to provide a "central core of theorising which is based on a rigorous review of related hypotheses after non-related ones are pruned away" (Glaser and Strauss, 1972).

The detailed hypotheses with which we started will generally be identified seriatim in dealing with each specialist issue or cluster of factors dealt with in this report. It may be useful at the outset to identify two fundamental hypotheses, however, with which we began.

(a) ***That part of the cause of women's low representation in the scientific and technological workforce is the direct responsibility of higher education institutions, and that the cause cannot wholly be blamed on the schooling system or on outside social factors.***

(b) ***That the institutional ecology of Universities and Institutes is a major factor in helping or hindering women's access to and progression in science and technology.***

The Sample Survey

The field work element of developing a model of institutional ecology, of statistical analysis of disciplines, and of reexamination of the ten core factors, has been carried out in ten Australian higher education institutions: five Universities and five Institutes of Technology. These were selected to meet a variety of criteria. The sample includes most of the principal providers of the country's scientific and technological workforce at tertiary level, and a representative sample from each of the five main States and urban population centres. Selection was moderated by the need to balance the sample between institutions with different provision as between Faculties of Arts, Social Sciences, Humanities, Science and Technology, Engineering, and institutions with different reputations for traditional approaches or for innovation and change. The sample also includes institutions at different points of development in relation to the existence of some degree of formal discussion, debate or policy on the status of women, and on affirmative action in science and technology.

This gave us a sample in five of Australia's seven capital cities as follows:

Name	City	State
University of New South Wales	Sydney	New South Wales
New South Wales Institute of Technology (NSWIT)	Sydney	New South Wales
University of Queensland	Brisbane	Queensland

Queensland Institute of Technology (QIT)	Brisbane	Queensland
Monash University	Melbourne	Victoria
Royal Melbourne Institute of Technology (RMIT)	Melbourne	Victoria
University of Adelaide	Adelaide	South Australia
South Australian Institute of Technology (SAIT)	Adelaide	South Australia
University of Western Australia	Perth	Western Australia
Western Australian Institute of Technology (WAIT)	Perth	Western Australia

The original design included only eight sample institutions because of limited initial resources, and the 1985 fieldwork was based on these. At the request of the Commonwealth Tertiary Education Commission (CTEC) we added two Western Australian institutions in 1986.

Since the 1985 and 1986 fieldwork, a major reorganisation of higher education in Australia has taken place, and all of the Institutes have been redesignated as Universities, mostly Universities of Technology. For the purpose of this report, however, we refer to them by their Institute designations and titles, not only because that was their status at the time, but because part of our argument about the impact of institutional ecology is precisely that there are a number of differences which emerge as between the Universities and the Institutes **as such**, because of their different history and cultural environments; and their different Faculty and degree patterns.

It should be made clear at this stage, however, that the policy review survey of ten higher institutions does not involve "case studies" as such. Three levels of data collection from the survey institutions have had three purposes:

(a) to produce a compilation of student and staff statistics representing a significant sample of Australian higher education in such a way as to answer **detailed, diagnostic** questions about female enrolments **in different disciplines and subdisciplines and at different levels;**

(b) to examine the **ecology of institutions** and of **disciplines** at a structural, policy-construction level;

(c) to explore the prevalent level of knowledge and attitudes in relation to the issues raised by this research, of some key academic staff in the higher education institutions, as a valuable source of field opinion. The

> intention was not necessarily to tap a representative sample but to draw on the leading practitioners for first hand evidence of factors or issues they believed to be relevant.

This will be more fully explained below. It should be noted here that we also wished to see if the practitioners in the survey institutions believed that there was a further factor or influence not already subsumed by our ten core factors, of which we should take note. In other words, the institutions have been used as a catchment area for the development of new theory, or for the amendment or reconstruction of existing theory.

The sample is a significant one. If we express the total number of students in engineering and science in the five Universities, for example, as a percentage of all Australian engineering and science students, they are 58.4 per cent and 36.4 per cent respectively of the total (CTEC, 1985[a]). The five Institutes of Technology in turn account for 50.4 per cent of relevant College of Advanced Education students; that is, they are 59.5 per cent of engineering students and 44.3 per cent of applied science students at the relevant level in the CAE sector (CTEC, 1985[b]).

Because of the complexity of the project, and the work involved for those institutions which agreed to cooperate, some steps were taken at the outset to establish an agreed context and method within which the UQ WISTA Policy Review project would work. Through the Vice Chancellor of the host University of the three-stranded project as a whole (the University of New South Wales), we obtained the formal approval and support of the Australian Vice Chancellors Committee (AVCC) and the parallel Australian Committee of Directors and Principals in Advanced Education, for the use of the sample Universities and Institutes of Technology as a representative and major sample of higher education institutions. Meetings were then arranged in 1985 at each institution, with the Academic Deputy Vice Chancellors or Directors, with Registrars and with other relevant senior staff. These had two purposes. Firstly, they were essential meetings to set out clearly the tasks which would need to be done each year for three years, their purpose and the degree of cooperation needed. Secondly, they provided the first round of group interviews of staff to discuss the key issues raised by our screening of earlier research, which we discuss later in this Chapter.

We defined a range of data which were seen as necessary for the exploration of the concepts (ecology, critical mass, structure of science etc) and the ten factors which were central to the enquiry; that is student and staff statistics, institutional data about the structure and organisation of Faculties and disciplines and special environmental information such as the state of the institutional debate or policy action programme on the status of women.

A Statistical Data-Base

We wished to set our research review of existing theory against a more diagnostic analysis of Australian data on the patterns of female enrolments and progression. This meant collecting data about staff and students subdivided not only by sex, but also to show

(i) ***institutional*** differences,

(ii) differences between ***disciplines*** and subdisciplines both between and within institutions, and

(iii) differences between ***levels*** of study in each of these.

While several relevant Australian studies have been completed since the early pilot work and design inception of the UQ WISTA project in 1984 (on which we comment in a later Chapter), there were no objectively researched Australian data which could answer detailed and discipline based questions other than at a very generalised level. For example, previous research has shown that generalised statistics hide very significant differences between higher education institutions. This provides also a *prima facie* case for supporting our conception that part of the answer to the issues we raise, lies in the different institutional ecology of higher education institutions.

Connolly and Porter's major American study of female recruitment to engineering, for example, looked at relevant factors across sixty different Schools. At the first level, their data established that there must be institutional factors of some kind which further influence female recruitment after the generalised effect of such social and educational factors as sexstereotyping in school curricula, family influence, sexpolarised careers advice and so on. Firstly, although their 1976 data showed a USA average female enrolment to engineering of 8.5 per cent of enrolments, four States fell below 5 per cent and eight States exceeded 10 per cent. In looking at sixty Schools of Engineering (small, under 500; medium, 500-1500; and large, over 1500) they found the ten most successful at enrolling women averaged 18.4 per cent but the ten least successful, as low as 1.6 per cent. And the interschool (and interdiscipline) differences remained constant over five years or more. Arguably, the reasons are more likely to lie with the Schools, the Universities or Institutes, than with the women. (Since this reported study, affirmative action in America has further increased female enrolments.) The researchers reached, inter alia the fairly obvious premise that "the strongest predictor of women in engineering at a given campus is the number they have attracted in the past". They developed this into what they term a *"positive feedback* hypothesis" which suggested that the presence of a "sizeable number" of women already ahead, serves to attract new women (Connolly & Porter, 1978[a] and [b]). This led the UQ WISTA research team to look at the need also to link the existing theories on role modelling with theories on the concept of critical mass.

A more recent study of postsecondary participation in Australia has also noted that the female proportion of University education will vary considerably across different higher education institutions, and would be affected by the range of courses offered in any one field and the alternatives offered by other faculties in the same University (Anderson and Vervoorn, 1983).

But Australian data have been more limited until recently, and have been principally available in relation to overall female participation rates by sector of education (Universities, Schools) or by Faculties (but not disciplines). One valuable Australian research review of women's participation in tertiary education which has been published since the UQ WISTA project started, for example, looks both at recent qualitative research in post-schooling and at trends in female enrolments in different tertiary sectors (Universities, Colleges of Advanced Education, Colleges of Technical and Further Education), but to examine contrasting institutional or discipline-based data at a diagnostic level was beyond that study's terms of reference and resources (Powles, 1986).

In Australia, however, as in America, institutions vary quite remarkably in the extent to which they succeed (or fail) in recruiting women to or retaining them in, the same discipline. Published Australian statistical analyses so far have concentrated on figures by **Faculty** (Applied Sciences, Arts, Medicine etc), which is unhelpful for qualitative analysis. Firstly, the basis for inclusion or exclusion in Faculties has no commonality. In one University, computing is located in Science, in another in Arts with mathematics (or both). Faculties of Medicine may include physiotherapy or pharmacy. In looking at male-dominated and female-dominated areas in 1984, we found that neither the published analyses from the Commonwealth Tertiary Education Commission nor those from the Australian Bureau of Statistics provided a breakdown which answered simple questions like:

(i) How many women (and what proportion do they form) are actually studying physics, chemistry, computing or mechanical engineering as distinct from materials or ceramic engineering?

(ii) How many (what proportion of) women are in which level in each discipline?

(iii)How many drop out, go on, etc? Are there different consistent patterns between disciplines?

One first order question was clearly whether there is a direct relationship (and if so, what) between different clusters of our ten factors of influence on the one hand, and the patterns of female enrolments in different disciplines on the other. To answer this, we clearly needed more detailed statistical analyses of the separate disciplines than could be supplied by the generalised Faculty enrolments.

Moreover, our theory of institutional ecology was based on a hypothesis that influences on women's perceptions of sexnormality or traditionality (which strengthen or weaken vocational and aspirational choice), include both the overall institutional sex-balance in the student body and in staffing, and the sex-balance in different disciplines.

One essential task was therefore to collect statistics which would show where women students were (or were not) enrolled in terms of discipline, level and programme. What were in fact their rates of access, progression, achievement in each of the disciplines? Were our hypotheses correct, that the same discipline would recruit differently in different institutions for structural, environmental or other reasons? Were progression rates different in the same institution, different for cognate disciplines, and why?

In 1985, institutions were sent a standard proforma setting out the figures we needed. We asked for the breakdown of male and female students for each level, and for the institution as a whole. This proved relatively easy. We then asked also for the number of women and men students studying in each of the survey disciplines which we had designated for each institution, and for the study as a whole. It proved, by contrast, much more difficult to achieve a common definition of what was a discipline, and a common agreement on how to define (for the purpose of this study), say, a maths student; when did one count chemistry or physics as such and when as a component of, say, engineering?

Since we were hypothesising that one influence on the cultural environment of the institution was the proportion to which women were a critical mass of the male-dominated whole, it was also necessary to look at staffing profiles. We have therefore obtained staffing figures for the institutions as a whole to show the overall sex-balance and for each discipline (discussed in our later Chapter on role model theory).

Statistical Profile

Overall male:female student balance in institution ⟹ Influences the cultural environment and therefore the overall institutional ecology

Female staff as proportion of the whole staff	⇒	Related to critical mass, role-modelling, mentorship, overall institutional ecology, and male or female attribution of discipline
Student data by sex, level and type (undergraduate, coursework Masters, research Masters, Doctoral) for institution as a whole and for each discipline	⇒	Related to critical mass, role-modelling, discipline ecology, attribution of disciplines as male or female, and image

The base year for the collection of student and staff statistics was the year 1985, as at 30 April 1985. Because in Australia the academic year runs from February to November (unlike Europe and America), an April date represents a midpoint in the first semester, by which the preliminary dropouts or transfers or changes will have taken place but before any significant attrition could be expected. The figures thus represent a realistic annual average.

For **student** statistics, we asked institutions to supply exactly parallel figures for 1986, which were collated and matched for 1985, discipline by discipline and level by level. In no institution and in no discipline was there a difference in the *proportion* of female enrolments between the two years of such a significance as to cast doubt on the normality of the 1985 figures. They are remarkably consistent in their patterns, and there is no evidence that 1985 was in any way a "freak" year.

In relation to staff statistics, our preliminary analysis provided a *prima facie* case for **rejecting** the current received wisdom that the mere presence of female staff as potential role models will as such increase female enrolments, as unsupported by the data. We therefore asked for staffing figures for 1985, 1986 and 1987 to complete our discipline profiles.

The study is about science and technology, and in our preliminary discussions with Registrars, Deputy Vice-Chancellors, Deans etc in 1985, we made it clear we were concentrating on students who, whatever the balance of individual *subjects* being studied, were expected to graduate with a degree in science and/or technology. That is, we were not interested in arts or commerce students studying one subject or unit of maths, computing or geology merely for interest.

It had been hoped that we could arrive at a common definition across the ten institutions. We succeeded in reaching a common agreement with all ten institutions that students from medicine, agriculture, veterinary studies and paramedical areas would be excluded from the survey altogether and from the figures for foundation subjects like physics and chemistry. Similarly, we asked that the returns for these subjects should exclude engineering students who take these subjects as part of a structured course.

For those interested in the raw data, a separate, statistical volume is available. We were not aiming to make value-based direct interinstitutional comparisons on any longitudinal basis, but to trace the different profiles of different disciplines as between types of institution.

The diagrammatic profiles which illustrate this report are based on statistical tables constructed from raw data supplied specifically for the UQ WISTA Policy Review project by each institution, providing as universal a presentation as possible. The tables were then sent back to the institution for checking and for appropriate further footnoting. Amended tables were then sent back to institutions for final vetting. At each stage, amendments to the original figures were made by institutions for one discipline or level or another. This time-consuming process was essential at every stage both to ensure accuracy and to eliminate any potential ambiguity of presentation. The principal differences of approach and definition have arisen as between those institutions whose degrees are more free-floating and composed of the most flexible choice or option systems, and those institutions with more structured degrees with stronger groups of specialisms or routes defined from the first year onward. Registrars were asked to ensure that Deans and Heads of Schools had the chance to comment on the draft tables at the stage at which, in 1986, the full set of statistical summaries for 1985 were available for each discipline or level and for each institution.

In 1987, the same process was repeated in respect of 1986 parallel data which were checked out by the institutions at the stage of compiling summary and comparative data.

Which Disciplines?

Much of the earlier research literature tends to refer to science and technology as if all disciplines carried the same image, profile, pattern of recruitment, or some kind of homogenous ethos. While some research on school science has differentiated between physics, chemistry and biology, in so far as different projects have centred on one or the other, more often attitudes have been tested about science as distinct from "non-science". Our early work on tertiary science and technology, however, including such limited statistics as were publicly available, suggested that differences in female and male participation patterns between disciplines in higher education were more widespread, more complex and more subtle. In reexamining the concept of institutional ecology, the UQ WISTA team have worked on *the ecology of disciplines*, the "ecological niche" of the institutional "ecosystem" as well as on the nature of science and technology.

In the original research design, the intention was to focus mainly on scientific or technological disciplines which had a tradition of poor female recruitment, and our original list centred on a core of very male-dominated areas like physics, chemistry and engineering. It then became evident that other foundation sciences were critical because they were "service subjects" as well as being sciences in their own right. Moreover, as concepts like territoriality, discipline image, sexneutrality or ascribed masculinity or femininity of disciplines emerged more sharply, it also became evident that some disciplines attractive to women would need to be included. Additionally, the research has been designed from the start as a policy-oriented project set in a context of the importance of technology and science to Australia's economic future. A third criterion of economic relevance therefore emerged. We discussed our preliminary list of disciplines suggested for inclusion with each institution at the first round of meetings with Deputy and Pro Vice Chancellors, Directors, Deans and Heads of Schools and Departments in 1985. As a result, some further disciplines were added either because they were of particular interest as acknowledged Centres of Excellence at the institution, or had unusual profiles, or were seen as of economic or political importance or political currency.

On these grounds the following disciplines were finally selected as those which would form the basis for collecting student and staff statistics and for discussion with academic staff, in the ten higher education institutions in the policy review strand.

Group A

Foundation subjects in science and technology which are both a discipline for study in their own right, and a service subject or prerequisite for degrees in science, applied science or technological disciplines like engineering or mining, that is: **mathematics**, **physics**, **chemistry**.

Group B

Disciplines which are clearly nontraditional and which recruit well below the 30 per cent cut-off proportion of female enrolment (maths, physics and chemistry also qualify under this criterion), that is: **geology, geophysics, mining, all branches of engineering, metallurgy, surveying and cartography, building surveying.**

Group C

Other disciplines seen as politically and/or economically important in the economic or political future development of science and technology, that is: **computer science, microbiology and biochemistry, biotechnology, genetics.**

It will be evident that we have excluded a number of disciplines which would otherwise qualify under one or more of these three criteria. This is for a variety of reasons. Firstly, some limit had to be set to avoid total unmanageability of data. Secondly, our prime focus is either on disciplines which, like higher education physics, consistently fail to attract girls (recruiting only one fifth of total enrolments from the equal half of school students who are female) or those which lose disproportionately more women, such as chemistry which recruits two fifths at undergraduate level, but tends to revert to the low level of other male-dominated subjects from the second undergraduate year and at postgraduate level.

We were also less inclined to include disciplines which attract girls and women already because we are not challenging the current received wisdom as to why they do enrol. Female recruitment to medicine or to psychology, for example, is held to be strongly related to societal sex-role stereotyping of the suitability for femininity of disciplines which are "caring", curative and about human experience rather than the perceived "objectivity" of thermodynamics or chemical analysis. The exclusion of medicine, agriculture and agronomy, of veterinary studies and of other disciplines which can be seen as scientific or technological, has therefore been based partly on their relatively lower relevance in relation to the three criteria of groups A, B and C defined above, and partly on their lesser likelihood to produce new insights which would enlighten policies for change.

DIALOGUE ON RESEARCH AND THEORY: A CATCHMENT AREA OF ATTITUDES AND ISSUES

It has been a matter of some interest that social science research, even when highly qualitative in nature, has tended to see a need often to authenticate its approval by locating its analyses of earlier theory wherever possible in standardised, quantitative, statistically controlled surveys. Where the required answers can be properly supplied by standardised computerised data ranked on a several point scale, this is, of course, sound enough. It does not, however, serve the purpose of all qualitative objectives. We used two methods to replace questionnaire techniques (a) group interviews and (b) the circulation of Discussion Papers to which staff were asked to respond.

That is, we have sought to build in a dialogue between two levels of thought which are perhaps a little less polarised than Medawar's (1972) perceived distinction between the imaginative and the critical. That is, we wished to set up a dialogue between the independent researchers creating theory in the area of women's educational underachievement or stereotypic channelling in science and technology, and the academic staff who actually play a role in constructing the discipline in higher education institutions.

(a) Group Interviews

Accordingly, we asked the survey institutions to cooperate firstly in setting up a series of ***group interviews*** in each institution in 1985 and 1986 with senior academic and professional staffs. The groups were to be not fewer than about eight and not more than about fifteen in number, and should include:

* as many as possible of the key policymakers from the Faculties or Departments in which our survey disciplines were located, viz Pro Vice Chancellors, Deans, Professors and Heads of Schools or Departments;

* other academic staff from the survey disciplines interested to come;

* professional staff in the areas of careers advice, counselling and student services and (where appropriate) Equal Opportunity staff.

The 1985 and 1986 meetings arranged with senior academic staff were not only set up in order to explain the complexity of the project and to negotiate agreements on the supply and verification of data. Also built in to this group interview process and into our written continuing dialogue with the ten institutions, was a "sieving" process using experienced academics as a form of field monitoring of previous research and of the reality of some of the more relevant research findings, in the normal higher education process. That is, we were applying Cohen and Manion's (1986) principle cited earlier that interpretive theory *"must make sense for those to whom it applies"*, and the pursuit of multiple hypotheses which Glaser and Strauss (1972) regard as central to field work which aims to lead to grounded theory.

Between nine and twelve meetings took place at each institution in both 1985 and 1986, except for the University of Western Australia and Western Australian Institute of Technology which were added to the survey in 1986 and therefore took part only in 1986 interviews. The one and a half hour meetings were all tape recorded, and an analysis completed of (a) the issues raised by academic staff in response to our agenda, (b) the comments, reactions, evidence and experience or judgements of academic staff on the ten factors which we raised in each meeting as potential influences, and (c) any new factors or issues raised by staff, not already covered by our work.

The group discussions were particularly useful in identifying the range of views, or a continuum of opinion, on controversial matters. Discussions sometimes identified polarised central views on some issues. For example, during the tape-recorded meetings with Deans and Heads of Schools in 1985 and 1986, there was a decided ambivalence on the actual role of a Dean or Head of Department. At one extreme, the view was taken that it was not in any way the function of a higher education institution or of its lecturing staff to consider where its clientele came from or how representative it was of the sexes (or social classes). *"It's my job to teach the law of Thermodynamics, not to indulge in social engineering"* (University physicist). At the other end of the spectrum, some Deans of Engineering had long since accepted that the institution had a role to play in both marketing its courses and in balancing the composition of its student body. *"We visit the girls' schools, go to Careers Days, we've published brochures with women engineers on the front, and we still don't get them in. Tell us what more to do and we'll try it."* Motivation for seeing a proactive role for higher education institutions in improving women's access and progression varied from an expressed acceptance that Universities are part of the social power structure of society and could legitimately, and indeed should, work consciously towards social as well as educational or economic goals, to a practical concern to increase undergraduate and postgraduate enrolments from the missing half of the age group to avoid wasted talent or to prop up a declining discipline.

The group interviews followed a semi-structured format in which an introduction of the project as a whole was followed by a scene-setting description of the main objectives and a sharply focussed introduction to some research findings on the ten factors.

We described our objectives as:

- to attempt to construct a model of institutional ecology as a transferable model for evaluation purposes;
- to obtain a range of specialist reaction and opinion from practitioners in the disciplines on the perceived or actual relevance of the ten factors to female student achievement in their disciplines;
- to help in a review of the realism, in applied terms, of the main findings of previous relevant research; and
- to canvass experienced field opinion on the appropriateness of different policy mechanisms which would help to redress the identified problems, and to test practitioners' views on priorities for action.

There was, however, a fifth general objective which we did not overtly identify. We wished to use the group interviews as an additional source to attempt to test the attitudinal climate of institutions as identified by their leading academics in the survey disciplines. What appeared to be the overt prevailing attitudes to women's roles in terms of traditionality and nontraditionality as described in the theoretical framework?

As part of this attitudinal climate, we wished to use the group interviews as an additional source from which to identify the apparent state of understanding of or exposure to the now considerable body of knowledge on women and science and technology, in the policymaking levels of each institution. It was for this reason that we requested that where possible, Professors, Deans and Heads should be invited.

We did not have the resources to conduct a full-scale survey on relevant attitudes, even if we had accepted that this was "scientifically" possible. We did hypothesise that in the same way that questionnaires are answered by the really committed (or responsible, or earnest), those who actually attended the meetings would be likely to represent the potential sharp end of change in the survey institutions. This was because an active voluntary response to an invitation to meet with accredited and sponsored academic researchers was perceived as more likely from:

* those *already interested* in or knowledgeable about gender-related issues in science and technology or involved in intervention strategies;

* those who accepted that female underrecruitment to science and technology was a current *policy issue* for higher eduction;

* those policymakers who accepted that tackling the issue was now an unavoidable *institutional goal* even if they were not personally convinced of a need;

* those who were in any terms normally at the sharp end of *generating change* in their institutions;

* those who were *curiosity-driven* or were *representing* more senior colleagues on request to ensure that their discipline's problems or experience would be aired.

We expected that such an attendance would ensure that a wider range of issues would be canvassed and aired. We believe that our expectation was justified?

How "representative" was the attendance at group interviews? The UQ WISTA team saw neither a need nor a realistic possibility of ensuring this (in the same way that one cannot necessarily ensure a representative sample of responses to written questionnaires). Attendance was not necessarily consistent either across institutions or across disciplines or between 1985 and 1986. But we were not expecting to generalise from the responses at interviews in the sense of seeking to argue that because a given number of mathematicians (physicists, geneticists ...) had considered one theory to be more valid, therefore most Australian mathematicians would so argue! We were, rather, seeking to ensure (a) that some hypotheses, conclusions and implications of academic researchers previously influential in policy decisions were measured for realism against the reactions of Australian academics actually doing the work of teaching in science and technology; and (b) that any factors not yet researched but seen as relevant, were aired by practitioners in institutions from each of the survey disciplines. We were seeking a **discipline view.**

(b) Discussion Papers on the Ten Factors

Our second strategy for testing knowledge and attitudes and for seeking informed opinion on needs and priorities, was to circulate a series of ten brief Discussion Papers (one on each of the ten factors) over a period from June 1985 to November 1987, to which academic staff were asked to respond in writing. The papers set out firstly to identify briefly the problem or issue (What is role-modelling and why is it important? Why is single-sex education or coeducation an issue in female achievement? What is the main problem about girls' achievement in mathematics?). We sought secondly, to report on relevant research in the area which was related both to female involvement in science and technology and to higher education; and thirdly, to pose questions which would as a result need to be addressed by higher education institutions. The papers were consciously limited in length to from four to seven pages to encourage academic staff actually to read them. Later Chapters refer in more detail to the content and coverage of these papers. Here, we illustrate their approach by examples of the questions we asked academic and professional staff to address as a way of sharpening their responses. In the case of Paper 4 on Prerequisites and School Curricular Choice, for example, we wished to clarify the difference between real prerequisites (ie one cannot cognitively learn and understand information-set B before having learned and understood information-set A) on the one hand and co-requisites (necessary in the longer term but can be learned equally well during several different phases of the degree) on the other. We asked the following at the end of the descriptions, definitions and reported evidence in the Discussion Paper:

> "In the context of the UQ WISTA survey, colleagues are invited to address the following questions.
>
> *(1) What are the established formal and non-formal prerequisites for your discipline?*
>
> *(2) Are all of these prerequisites, or is it possible for students to make up the missing knowledge*

concurrently after entry? Which subjects/elements are prerequisites and which requisites?

(3) How can we improve the knowledge of school teachers and careers teachers about the critical filter effect of prerequisites? How can we ensure they know the real prerequisites for different disciplines or branches?

(4) What is the role of a University or Institute in providing bridging or topping up courses? What are the resource implications of this?"

In the case of Paper 10 on The Image of Science, by contrast, we raised a number of aspects of image, including the issues of social responsibility and the perceived "maleness" etc described in Chapter I, and asked:

"(1) Do you consider that your discipline has a major image problem which affects recruitment? If yes, is this connected with its male/female attribution, and/or its social responsibility image, and/or its anachronistic image?

(2) How is discipline-image most strongly transmitted? By the media? School books? Careers advice? Higher education handbooks and marketing?

(3) If you had to rank your discipline on a three-point scale

Male	-	***Sexneutral***	-	***Female***
1		***2***		***3***

where would you rank it?

(4) How most effectively could your discipline-image be improved? By higher education staff? Professional institutes? School staffs? The media?"

Each of the other eight papers ended with a similar set of questions.

The responses received in writing from a wide variety of staff (from Deputy Vice Chancellors to lecturers) have been analysed in a policy analysis framework.

(c) Institutional Profiles: Discipline Profiles

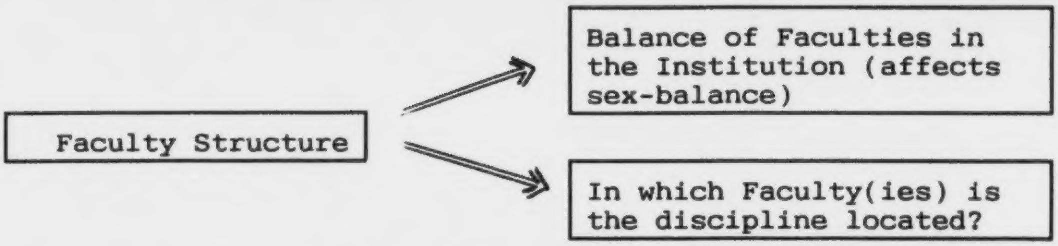
We set out to look holistically at several levels of data and interpretation in the survey institutions. This involved looking at some aspects of the structure of institutions and of disciplines. We wished to see whether, and if so how far, the differences in statistical patterns of staff and student female involvement in science and technology could be correlated with differences in Faculty structures or with differences in focus and content of the same discipline in different institutions.

As a result of earlier research by the principal researcher, and of the research literature review conducted by the UQ WISTA project in 1985, we set out with a number of hypotheses in mind in this context. Firstly, it was considered possible that the proportion of female enrolments (including the attainment or otherwise of critical mass) might be causally related to the Faculty location of a given discipline. For example, earlier research has reported that proportionately fewer girls than boys enrol in applied subjects as distinct from subjects described in more free-floating and general terms. We wished to cross-check the level of female enrolments in allegedly sexneutral disciplines like computing, or in variable disciplines like mathematics, against their institutional location in Faculties of Science, or in Applied Science or in Technology. Was there a correlation in our survey disciplines?

We noted some marked variations in the construction and content of disciplines like chemistry, computing and geology. The same discipline was consciously described as contrastingly applied or foundational in two different institutions, for example, and disciplines like biotechnology were marketed as people-oriented or issue-centred in one institution and as content-oriented and more abstract in another.

Different levels of data have been related to construct **"Profiles"** of each institution, and Profiles of each discipline, in the context of UQ WISTA's hypotheses and issues, which would serve the purpose of integrating the data in such a way as to improve our understanding of potential relationships. Put another way, our **grounded theory** needed to be set not only against the sectional data (staff figures and student figures, for role-model theory; discipline statistics, for image) but also against *related sets* of several levels of institutional data.

We have checked the location of each of our survey disciplines to identify in which Faculty it is located (and marketed) - for example, is computing marketed as a free floating discipline in the Science Faculty? Or as an applied discipline in Applied Science Faculties? Or in Engineering Faculties, related to Electronic Engineering? The balance of Faculties in the institution, also affects the overall sexbalance (large Arts/Humanities Faculties recruit more women than men: institutions with mainly technological Faculties are male-dominated as a whole).


Faculty Structure
Balance of Faculties in the Institution (affects sex-balance)
In which Faculty(ies) is the discipline located?

The Feeder System: Secondary School Curricular Patterns

Without detracting from the UQ WISTA project's focus on the role of **higher education** in encouraging female achievement and in remediating or counteracting sex-role stereotypic secondary education, it was seen as essential from the onset to check the male and female patterns of curricular options at Grade 12 in secondary schooling in each of the States in which the survey institutions were located. It would be hardly reasonable to expect higher education to produce substantially more science specialists than the schooling system exported, even allowing for mature entrants, overseas enrolments and bridging courses.

We have therefore obtained. with the cooperation of the Boards of Secondary School Studies (or equivalents) in each of the States, data on the male and female Grade 12 enrolments in relevant feeder subjects for 1985, the project's base year, and for later years. Some of this data goes further than overall State figures and we look also at the relationship between structure and content of some of the Grade 12 subjects and proportionate female enrolments. The pure:applied antithesis emerges again here in the results, as a relevant sex-differentiated indicator.

The secondary data have been used to enlighten our grounded theories in relation to four of the ten core factors, that is male and female attitudes to science, prerequisites, maths as a critical filter and career guidance.

Where necessary, other methodological issues will be clarified seriatim as we deal with different clusters of factors or issues.

REFERENCES

Anderson, D., and Vervoorn, A. (1983) Access to Privilege: Patterns of Participation in Australian Post-Secondary Education, Australian National University (ANU) Press, Canberra.

Bensman, J. and Vidich, A. (1972) "Social Theory in Field Research" in Filstead, William (Edit) Qualitative Methodology: Firsthand Involvement with the Social World, Markham Publishing Co., Chicago (3rd Edition of 1970 original).

Borg, W.R. (1963) **Educational Research**, Longman, London.

Cohen, L. and Manion, L. (1986) **Research Methods in Education**, Croom Helm, London (Second Edition).

Commonwealth Tertiary Education Commission (CTEC) (1985[a]) **Selected University Statistics, 1985**, AGPS, Canberra, Table 3.

CTEC (1985[b]) **Selected Advanced Education Statistics, 1985**, AGPS, Canberra, Table 6.

Connolly, T. and Porter, A.L. (1978[a]) **The Recruitment and Retention of Women as Undergraduate Engineers**, Research Report, Georgia Institute of Technology, Atlanta, USA.

Connolly, T. and Porter, A.L. (1978[b]) **Women in Engineering: Policy Recommendations for Recruitment and Retention in Undergraduate Programs**, Research Report, Georgia Institute of Technology, Atlanta, USA.

Glaser, B.G. and Strauss, A.L. (1972) "Discovery of Substantive Theory: a basic strategy underlying qualitative research", Chapter 28 in Filstead, William (Edit) **Qualitative Methodology: Firsthand Involvement with the Social World**, Markham Publishing Co., Chicago, 3rd Edition of 1970 original.

Kerlinger, F.N. (1970) **Foundations of Behavioural Research**, Holt, Rinehart and Winston, New York.

Medawar, P.B. "Science and Literature" in Medawar, **The Hope of Progress**, Methuen, London, 1972.

Merton, Robert (1958) **Social Theory and Social Structure**, Free Press, Glencoe (Revised Edition), pp.5-6.

Nagel, E. (1961) **The structure of science**, Harcourt, Brace and World, New York.

Powles, Margaret (1986) **Women's Participation in Tertiary Education: A review of recent Australian research**, Commonwealth Tertiary Education Commission, Canberra.

CHAPTER III

INSTITUTIONAL ECOLOGY AND WOMEN IN SCIENCE

> ***"If you want to slip into a round hole, you must make a ball of yourself - that's where it is."***
>
> George Eliot, The Mill on the Floss

It has been just so since the first introduction of organised secondary and higher education in the 19th century, and of systemic education in the twentieth. That is, new kinds of entrants to existing schools, colleges and Universities have been expected to knock off any corners and to replace any cultures, manners or discourse which do not fit the dominant existing pattern. Any failure to adapt not only to the criteria but also to the behaviour for selection, risked failure of access. Any failure to adapt after entry was highly correlated with dropout. One of the most vivid exposés of this process was documented for working class children in grammar schools in the 1950s and the effect of their adaptation or otherwise to the different *culture* of middleclass education (Jackson and Marsden, 1962). Sociologists, and notably Bourdieu, have further explored the mismatch between the experience and background of the new cohorts of working class students entering the Universities in the 1960s, and the different forms of discourse which appear to be generic to the dominant higher education culture. We will be suggesting in this Chapter that the discourse of most higher education scientific disciplines is not only class-based (in Bourdieu's terms), but male-dominated and masculine in *culture*.

It has been most imperfectly understood that this match:mismatch issue is not only a class issue, but also applies to female students entering a male-constructed higher education system inherited in turn from the patriarchal culture of the 19th century. The patterns of discourse, of peer group behaviour, of teaching and learning with which most male students are at ease, have proved to be significantly different from those into which most female students have been socialised during the years of schooling and of late adolescence. The male-as-norm process is deeply embedded in higher education culture. Discourse is only one aspect of culture, of learning environments and therefore of *institutional ecology*.

INSTITUTIONAL ECOLOGY

If a plant fails to flourish, to grow or even to survive in our human-constructed garden, we do not blame the plant. We examine the soil (appropriate? needs more lime or phosphate?); the position (needs more sun, or shade, shelter or exposure); the nutrition (too strong? too weak? too wet or dry?) and so on. We accept that it is we who have created an inappropriate ecological environment and that we must adjust that environment if plants, other than the indigenous hardy ones, are to survive and flourish. Yet we refuse to accept a parallel responsibility for the learning environment that we create.

This Chapter discusses a new approach to institutional ecology which may help better to explain both why women are where they are in science and technology; and why they are not where they are not. We believe that in using ecology theory as an explanatory framework and as an extended metaphor, it is possible to achieve greater insight into why women's access to and progression in different scientific and technological disciplines varies so significantly as between disciplines, between levels and between institutions.

Previous theory has accounted for girls' unequal access or entry to certain scientific disciplines and women's lesser rate of progression to most areas of postgraduate scientific and technological study, by a wide range of factors and influences - from one extreme of assumed psychological or biological innate sex-differentiation, to the other extreme of socially constructed conspiracy theories. But factors such as sex-differentiation of teacher:pupil interaction (pedagogic), parental discouragement (social stereotypic), girls' alleged poorer mental equipment for mathematics (alleged biological predestination), single-sex versus coeducation (pedagogic and structural), male discouragement of girls and male territoriality (attitudinal), cannot adequately explain **why inter-institutional and inter-disciplinary differences are so great.** Why do girls from similar schools, social backgrounds, temperaments, enrol consistently more highly in some institutions than others? In some scientific disciplines more than others?

Physical Environment: Limited Influence

Some earlier researchers have explored institutional ecology as a physical environmental issue, assuming that this impacts significantly on student behaviour. Some feminist theory, for example, has attempted to argue that girls are more put off than boys by an unattractive institutional environment (for example, concrete-massed, unsoftened by landscaping or decor). There is little formal research which records gender differences in this area, and we remain mildly sceptical about its actual importance in terms of UQ WISTA's hypotheses on access and progression. Nevertheless, some of the research is worth a passing glance.

One American model, for example, looked at the ecosystem concept in higher education almost entirely in terms of the physical environment. The United States Western Interstate

Commission for Higher Education (WICHE) developed an ecosystem model whose basic components were (i) assessing student perceptions of their environment, (ii) soliciting recommendations for changing their environment, and (iii) redesigning the environment to meet student needs (Schuh and Allen, 1978). The approach is instrumental, based heavily on measurement of student perceptions and actual physical environs. The WICHE Task Force on Epidemiology, Campus Ecology and Program Evaluation saw influences on student performance or adaptability as purely a matter of physical environs, since it addressed the issue in 1973 in terms of campus redesign "to accommodate a variety of lifestyles" (WICHE, 1973). The five main issues highlighted by students for policy change in Schuh and Allen's (1978) model were an expanded meal service, new policies for room decoration, facilities for quiet study, facilities for "intense study" and security protection for students on campus at night. Surprisingly, given the state of debate in the mid 1970s on women's relative underachievement in higher education, neither of these studies looked at sex-differences in attitudes to environment, nor at the impact of peer group pressures or staff attitudes and styles, on the learning or cultural environment.

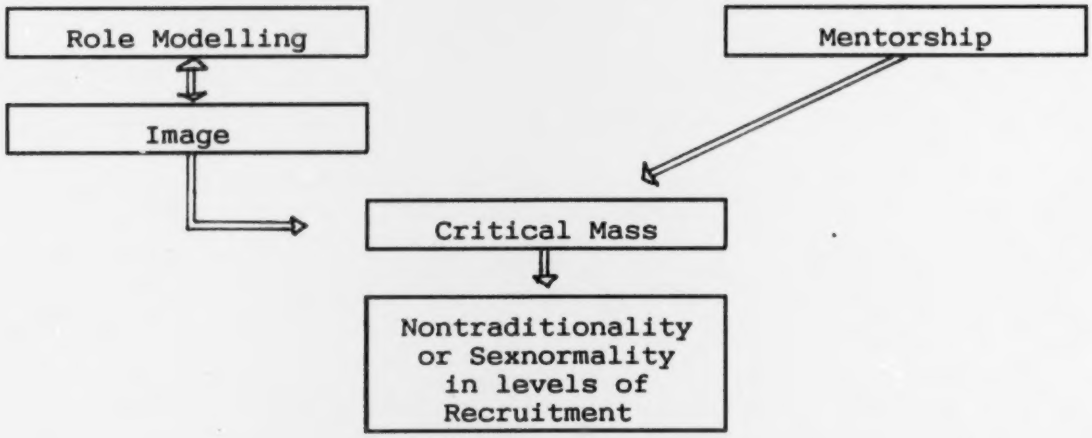
The now massive literature on sexrole-stereotyping in the years of schooling tends to suggest in general terms that girls are conditioned to become more susceptible to environments which are civilised, comfortable, clean and softened by decor; and are conditioned to be put off by concrete, dirt, steel, oil, machines and mud. It is, however, difficult to trace any hard, empirical research evidence which validates a cause-and-effect sex-differentiated relationship between harsh or unattractive physical environments and female demotivation in academic learning, in higher or tertiary education institutions. Reports of projects (as distinct from systematic structured research), often weak in methodology and rigour, report frequent *assertions* that girls' alleged poor motivation to study the manual crafts, engineering, surveying and geology, is influenced by their (perceived) dislike of rough, oily or muddy surroundings. We were prepared to accept some validity in this in relation to ***image***. That is, we were prepared to look at a hypothesis that lower female enrolments might be progressively correlated with disciplines presenting a harsh or unfastidious environment in their image (however incorrectly the image describes actual disciplines and their real work). But are girls and their parents *really* influenced in advance of application by perceptions of a campus as dominated by laboratories, formaldehyde, rats and machines on the one hand, or of leatherbound books, seminars, comfortable common rooms and philosophy on the other? We were less convinced that the reasons why University A had higher female enrolments in physics, geology or electrical engineering than Institute B, would include that University A is softened by green lawns, jacaranda blossom and pleasant student facilities while Institute B is an inner city concrete jungle round a massive tower block full of grey box-like small rooms with student facilities in a lower basement. While the hypothesis could, we judged, stand some testing in a wider, more integrated model of ecology which we were developing, we saw the main issues as more complex and more cultural.

We therefore discounted it as a factor relevant to access, and have not pursued this aspect, although we were less ready to discount it as a factor influencing retention or dropout, progression in a discipline, or transfer out of it. Since physical environment may contribute to cultural environment, we kept an open mind on its relevance to adaptation theory; but ranked it hypothetically low on our list of influential factors, except in regard to male peer behaviour in territorially dominating hands-on facilities in laboratories and computer rooms.

Reviewing Institutional Ecology

We now turn to the resetting of ecology theory in the context of this study. In essence, it is argued that the ecological environment of certain scientific and technological disciplines is the major determinant in both successful recruitment and progression, or failure to recruit; in progression or dropout. By analogy with natural ecology, in which elements and factors such as warmth, cold, moisture, dryness, soil composition, exposure, shelter, are determinants of both survival and growth, we argue that there are clusters of factors which are common to most, and specific factors more relevant to some disciplines than others, which are determinants for women students. One such "primary" cluster is, for example:

CLUSTER (1)



That is, women will see a discipline as sexnormal if critical mass is achieved. Factors influencing the achievement of both critical mass and sexnormality are image and rolemodelling and mentorship, some of which have two-way as well as one-way relationships. Cluster (1) can operate at both institutional and discipline levels. We return to this later in the Chapter. Here, we first set out an ecological approach to explaining higher education culture, and therefore, patterns of access and progression.

There is, of course, nothing new about human ecology theory. Some thirty years ago, Duncan described human ecology as having four principle variables. Population, organisation, environment and technology were, he argued, characteristics of an ecosystem. He saw these as reciprocally connected (Duncan, 1959). One of the elder statesmen of human ecology theory, Amos Hawley, argued that it was concerned "with the elemental problem of how growing, multiplying beings maintain themselves in a constantly changing but ever restricted environment ... the subject of ecological enquiry then is the community, the form and development of which are studied with particular reference to the limiting and supporting factors of the environment ..." (Hawley, 1944, p.403). In this sense, the study of science and technology in the higher education ecology, or the discipline ecology, is a study of those communities and their limiting and supporting environmental factors. It is a study also of institutional culture, which Hawley (1944) described as "nothing more than a way of referring to the prevailing techniques by which a population maintains itself in its habitat ... the morphology of collective life in both its static and its dynamic aspects" (pp.403-404).

Further to reinforce the paradigm shift of which we spoke in Chapter 1, from girls and women (the "organisms") to the male-constructed environment (the ecosystem or ecological niche), it should be noted that later human ecology theory has developed the concept of collective relationships in the environment: "organisms, whether plant or animal, establish viable relationships with environment, not independently but collectively, through the mechanism of a system of relationships" (Hawley, 1968, p.328). We are arguing that it is precisely these collective relationships which are a major influence on female and male achievement and progression in science and technology in higher education: male peer pressures on female peers, sociometric patterns, discourse in collective settings. We also argue that the ecology metaphor explains in considerable measure why the consistent small minority of women who are successful in each generation in carving their way up to the professoriate or to top management, do in fact get there. Like Darwin's organisms, those who survive are likely to be those that evolve characteristics that are compatible with the environment: in this case, assertiveness, competitiveness, discourse modelled on "masculine" styles rather than "feminine" modes; instrumental values rather than people-oriented values.

Hawley, writing in the 1940s, also reviewed contemporary perceptions of human ecology as dealing with sub-social phenomena. There were, he argued, "some writers who would have human ecology encompass the whole field of social science, and there are others who prefer to relegate it to the status of a mere sociological research technique" (Hawley, 1944, p.398). The 1940s debate centred around a typical controversial debate with mutually exclusive standpoints. One group argued that ecology offers an essentially biological approach to the study of the human community and related human to general ecology. The other strongly opposed even a suggestion of association or similarity between the two on the grounds that any assumption of analogy as between social and biological phenomena was invalid and impractical.

Hawley rejected both stances, asserting on the one hand that the concept of "the sociological quality of the idea of struggle" does have direct biological analogy: according to Darwin, the struggle for existence relates primarily to the behaviour of organisms to one another. "If this be the province of biology, then *ipso facto* all social science resolves itself into biology" (p.400). But on the other, he rejected the concepts of competition and spatial analysis as central pivots of human ecology.

In defining the theoretical analogy against which our own policy analysis would take place, the generic definition of ecology has been accepted as "that branch of biology which deals with the relations of living organisms to their surroundings, their habits and modes of life" (Shorter Oxford English Dictionary, 1978). Environment is taken to be "the conditions or influences under which any person or thing lives or is developed" (1827 from SOED, 1978). We discuss both human ecology and institutional ecology at two levels. Firstly, there are valid *analogies* to be drawn; secondly we will use, in looking at microbial adaptation to new cultures as a transferred metaphor, the concept of an *extended metaphor* to aid interpretation at a phenomenological level.

We found the biological definition between **autoecology** and **synecology** a useful one in terms of an extended metaphor for interpretation. Autoecology is the study of individual living organisms and their environments, while synecology studies the relationship between living groups and their environments. One legitimate criticism of the available pool of previous research could well be that past researchers have been more interested in studying the autoecology of science students and the functioning of individuals (to see why they do or don't succeed or acquire positive attitudes or motivation), rather than the synecology of dominant and subdominant group interactions, in institutional or systemic terms.

In looking at **institutional ecology**, we have used the basic analogy of an ecosystem (which we are defining as the institution), in which organisms (new women students) adapt to their new cultures and are found in "ecological niches", which we are defining as the discipline, School or Department. In this we differ from Stern (1970) who based his analysis on "the college as an ecological niche" (our emphasis) whereas all of our preliminary work convinced us that if role-modelling, mentorship, cultural attitudes etc were critically influential, it was at discipline or Departmental level. In this, we ally with Hannan and Freeman who define the ecological niche in terms of human development as the area in which a particular population group (in our case, minority women) "can survive and reproduce itself" (Hannan and Freeman, 1977, p.947). And we argue that the achievement of critical mass is essential for this ability not only to survive (ie to continue and to complete), but also to reproduce a larger cohort in the next generation through the achievement of a sexnormal image and perception, in place of nontraditionality.

There is, of course, nothing new about theories of institutional influence (in terms of environmental impact) on student attitudes and performance. There are several themes which run through the relevant research literature and theoretical studies. One is the unevenness of the ecological environment of education, as between regions, districts, institutions. Both the theories of Connolly and Porter (1978) referred to earlier in relation to critical mass, and Eggleston's work on the ecology of schooling, raise issues of the different influences on both access and attainment that different institutional environments exert. Eggleston's study took the concept further. His apparent oversimplification that "the ecological approach ... springs from ... the basic understanding that human beings take on different patterns of behaviour and different life styles and accept different patterns of achievement when they find themselves in different locations" is developed into a clearer definition of the "ecology of power in a society or community" which in turn requires study not only of the response of individuals to their environment, but alterations in the creation, maintenance and distribution of the resources (human and material) which constitute the educational environment. Eggleston reaches a depressing but realistic view that "there is no evidence that individuals seek through their perceptions, their interpretations or their intentions, to challenge the ecological system of schooling or of the society of which it is part" (Eggleston, 1977).

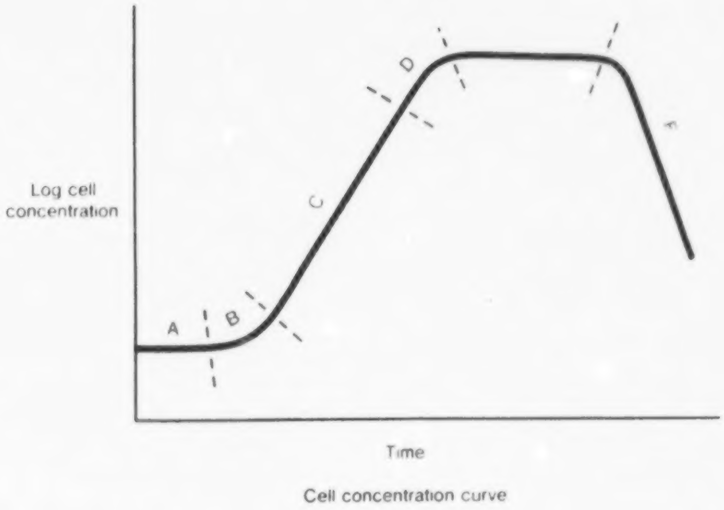
We have reviewed some earlier models which have been reported as useful in investigating ecology or environment in the context of education or training. We have not, however, found an existing model which would provide a valid way of interpreting holistically the clusters of factors which we have seen as interrelated.

Some researchers appear to have replicated the linear approach referred to in our introductory Chapter - single dimensional studies, for example, looking at physical environment, but not simultaneously at behavioural, structural or cultural influences in higher education institutions.

A further analogy can be identified with microbial adaptation to physical cultures. **Let it be said at the outset that at no point are we arguing a direct transference of "behaviour" as between microbes or plants and human students!** We are simply using a relevant conceptual analogy in the form of an extended metaphor, to enlighten and to requestion some received wisdom about the operation of the management of higher education institutions.

When microbes are placed in a new culture, cell growth takes place only under particular conditions. Microbial growth depends not only on physical factors like warmth, humidity, but also on the absence (or presence) of **bacteriostatic** agents which inhibit growth but on whose removal, growth resumes, or of **bactericidal** agents which will kill the bacteria off completely. Thus far, we argue that women's retention and progression in nontraditional disciplines is vitally affected by the presence of "bacteriostatic" or "bactericidal" agents in the shape of nonsupportive or aggressively critical lecturing staff or peer group males, whose role in this regard we discuss in later Chapters in discussing attitudes and mentorship.

Also useful as an analogy is the microbial phase of adaptation which includes a "lag phase". Jawetz et al (1984) represent the microbial phase of adaptation, growth and decline as in the figure below:



Cell concentration curve

Figure 3.5 Time-lag theory
(Taken from Jawetz et al, 1984, p. 93)

Phase A is the "lag phase" when, as Jawetz et al put it "the cells ... adapt to their new environment... If the cells are taken from an entirely different medium, it often happens that they are ... incapable of growth in the new medium. In such case a long lag may occur ..." (op.cit. p.93).

When microbes are in the lag-phase on entry to the culture, their energy is first spent on adaptation and is therefore not yet available for cell-growth. Only when they have adapted, will they move to phase B and multiply. Moreover, **the more the culture is identical with or similar to the culture from which the microbe came or to which it is accustomed, the shorter the time-lag phase.** Similarly, the more unlike or dissonant the culture, **the longer the time-lag phase.**

Van Demark and Batzing (1987) describe the lag phases as "a period of rejuvenation or adjustment prior to the onset of cell division ... in a new physical and chemical environment to which the inoculum must adapt". If cells are transferred to a fresh medium of the same composition, they "initiate growth with virtually no lag" (p.180).

By analogy, if the teaching style, teacher attitudes, behaviour patterns and cultural environment are very similar to that from which new students come, the less their time lag of adaptation, and vice versa. We will argue that girls entering the scientific and technological disciplines, come from a more dissonant culture and boys from a similar one.

When, in microbial processes, cells that have been inhibited by a bacteriostatic agent are removed from the harmful cultural environment, washed thoroughly in a centrifuge and replaced in a new growth medium, they begin growth again. So when women students transfer during or after the first year to pursue maths/arts instead of maths/science, or to pursue biological sciences or biochemistry and to drop chemistry and physics, they are removing themselves from a culture which they find alien and negative to their personal and intellectual development, to a culture which encourages growth by being more similar to that of their secondary schooling years. We believe this to be cross-related also to the question of the structure and content of disciplines.

The biological metaphor must, for validity, be set against a number of assumptions about the incoming school leavers and their previous school and adolescent experiences. Firstly the ethos made up of teaching style, discourse patterns, culture and actual male participation rate of disciplines like physics, engineering, geology, construction, is most likely to replicate that of the single-sex boys' non-government schools from which a majority of male school leavers entering science and technology Universities in Australia come. Secondly, the ethos of the physics and chemistry Grades 11 and 12 classes of the coeducational high schools from which the remaining male students come, also matches the dominant culture of groups in which males outnumber females. We write more of this in our forthcoming more detailed research reports on mathematics, prerequisites and the single-sex v. coeducation controversy. The point here is that males entering science and technology are entering a culture **in which they need no time-lag to adjust** because it matches that from which they came.

Girls entering from a single-sex girls' school are held, by current received wisdom, to have an advantage over those coming from coeducational schools. There is, however, no sound empirical base for this yet in Australia. Unless and until longitudinal research following several different cohorts and control groups were to track the intakes through the transition from general first year studies to specialised second year (and to check why the choices were made), from third year to honours and, where appropriate, to completion of a Doctorate, we simply cannot assert that single-sex schools necessarily produce more women physicists or geologists. (And investment in such research would not be justified in policy terms since entry to secondary school is not controllable as a policy issue.) The girls from single-sex schools, moreover, come from a cultural environment where the style of discourse and interpersonal relations has developed throughout adolescence in a very different manner from that of an all male or mainly male learning environment. Thus, they enter a different culture in tertiary science and technology from that from which they came. Girls coming from coeducational high schools have already been exposed to classes in maths and science which are male-dominated and conducted in styles of discourse and teaching which sit more easily with boys than with girls. Some will have learned to adapt to the male norm (which we describe later in this Chapter) and some will be less secure. We hypothesise that one determinant of continuation and progression, as against dropout or transfer, is the extent to which such an adaptation has or has not taken place before entry.

If, of course, higher education institutions accept responsibility for resetting the learning environment, discourse and mentorship roles during first year teaching into a more sexneutral mode, this becomes realistically remediable. This includes understanding of the need for a time-lag phase for adaptation - from which boys coming from learning environments less aggressively male (eg small rural high schools with a high proportion of women staff) will also benefit.

Cameron (1984) discusses organisational adaptation in higher education in the context of ecology theory. He differentiates *organisational development*, which focuses on changes which are motivated from within the organisation: changes in attitudes, behaviour and culture, from *organisational adaptation* which arises from changes in the external environment which require institution-level changes in turn. It is this second which characterises the gender issue: few or no higher education institutions have willingly and organically changed to accommodate new clientele, without substantial direct or indirect pressures from outside (from legislation against discrimination or for affirmative action, to pressure from new community standards of gender equality) organisational adaptation is primarily reactive, organisational development is proactive.

Within the overall theory, population ecology approaches to adaptation, focus on environmental niches within organisational structures.

Cameron interprets the population ecology approach as one in which "the fittest species - those that evolve characteristics that are compatible with the environment - survive, while other species become extinct". But management is precisely about *controlling* the organisational culture and environment, mostly incrementally rather than by the major shifts caused by radical or revolutionary measures. Higher education in particular is an exceedingly change-resistant, inertia-prone environment compared with industrial and commercial enterprises.

Hannan and Freeman (1977) discuss and analyse population ecology models at three levels: individual, population and community, and their approach supports the use of "niche theory" as a way of focussing on different populations and their ecology, within organisations as well as between them. They postulate three dimensions by which we can measure the "blueprint", as it were:

* the formal organisational structure;

* patterns of actual activity within the organisation; and most relevantly,

* the ***"normative order - the ways of organising that are defined as right and proper"*** by members and sectors within the organisational environment.

In terms of the UQ WISTA project, we set out with a belief that the "normative order", in Hannan and Freeman's terms, of those disciplines which fail to attract or keep women students, are constructed in a way that is ecologically user-unfriendly to girls and women in ways which we will discuss in more detail in specific Chapters. We also believed that there were different "patterns of activity" as between the scientific and technological disciplines that do and don't attract women. This, we hypothesised, meant in turn that in Cameron's (1984) terms, only those women students who evolved the "characteristics compatible with the environment", survived (ie, did not drop out or transfer to other courses or disciplines). We therefore worked on the basis of seeking how the *environment* of the ecological niches of those disciplines needs to be changed: rather than requiring the "species" to adapt to an inappropriately constructed environment - for while we cannot change geographical and sociological ecology without major ricochet effects, the same does not apply in the same measure to University education.

How then can we identify or measure the relevant ecological factors in higher education?

LEARNING ENVIRONMENTS

The learning environment is highly relevant to student aspirations. This operates at both institutional and Departmental or discipline levels. The premise that "the environment of a university is shaped by the totality of the university's programs, personnel, policies and procedures which are designed to promote learning" (Gaff, Crombag and Chang, 1976), is one which we endorse and which underlies the construction of the UQ WISTA model of institutional ecology. In terms of the issues which UQ WISTA investigated, the institutional learning environment was seen as influenced by a number of factors:

(a) The ***attitudinal climate*** as set by the **dominant** groups of academics and students. To the extent that there is male domination, if we accept the prevailing research evidence that there are general differences in teaching styles, manners of discourse, values inculcated and behaviour patterns as between mainly male and mainly female groups, then women entering the prevailing attitudinal climate of physics, geology, engineering, will experience a mismatch on entry.

(b) The ***construction of disciplines*** as free-floating or highly structured, as pure or applied, as vocationally-oriented or as curiosity-driven.

(c) The ***image and marketing*** of disciplines as socially responsible or otherwise: as sexnormal or nontraditional.

(d) The ***academic staff***, their representation in terms of sex-balance, (in terms of visibility, role-modelling, mentorship) and their teaching styles as related to different disciplines.

(e) ***Peer group*** behaviour, notably by males to females and by dominant majorities to minority groups who are not yet a critical mass and/or whose culture, behaviour and style differs from the inherited norm.

There is some previous research which has investigated the characteristics of the learning environment at Departmental as well as institutional level, but with results which provide an ambivalent basis for generalisation. In Wakeford's (1984) study of student perceptions of twenty-five British and Irish Medical Schools across eleven dimensions (from flexibility and friendliness to course content and ethics), the Schools showed variation on three dimensions: extra-curricular emphasis, intensiveness and a "vocational versus scientific" orientation. (Some schools taught medicine in a vocational ethos, others with a more enquiry-oriented scientific approach). However, Wakeford does not report his results at all qualitatively. The inter-School differentials on vocational orientation as compared with students' freedom to explore their interests are relevant to this study, although no sex differential was explored in Wakeford's study.

We spoke in Chapter 1 of the perceptual distinctions generally drawn between science and non-science, science and technology. Here, we refer to distinctions between those disciplines which are highly structured and codified and those which are seen and designed as more free-floating and enquiry driven (in terms of students' capacities to follow their own interests). Previous research does show a marked and relevant sex-differential according to these distinctions. Review of studies on female access, dropout, progression, shows that girls enrol proportionately less than boys in subjects described as *applied* (applied rather than pure maths, applied geology, etc) and less in subjects marketed as *vocational*. The UQ WISTA data supports this theory. The question of student interest as a motivational factor is also sex-differentiated. Researchers studying adolescent motivation and/or aspiration in school students have reported over some decades that proportionately more girls will choose school subjects or disciplines for intrinsic or interest-based reasons ("I like it", "I am good at it", "I am interested in this"), while proportionately more boys tend to be guided by extrinsic (usually vocational) reasons of usefulness, relevance to future work, or preparation for higher education studies ("I need it for my job", "maths will be useful", "it's a prerequisite").

Thompson et al (1969) argue that the natural sciences have a more highly codified body of knowledge which is now rooted in clearly defined and accepted methodologies, than the social sciences or humanities. They hypothesise as a result that this accounts for differences in the extent to which different disciplines are responsive to the needs and interests of students. Our inclusion of structure and style of discipline is supported by Gaff, Crombag and Chang's (1976) study of four Departments in a Dutch University, in which chemistry emerged as leaving little time for "free-floating" critical enquiry or discussion. Chemistry teaching was reported as knowledge-oriented and prescribed and so heavily and tightly timetabled as to leave little time for student-controlled work or for personal academic interests. The Departmental style as described by students, emerged as instrumental and inflexible. By contrast, in the same survey, the Psychology Department is described by the researchers as having a "freewheeling, independent atmosphere". This contrast was sharpest in the time required of students for set, controlled work; highest for chemistry and lowest for psychology of the four disciplines surveyed.

It is not only women who show a will to reject the artificial constraint of knowledge into a straitjacket of what Lowe and Worboys (1980) call "the objective, rational and calculating consciousness" in favour of "a more subjective, intuitive and feeling type of knowledge". Lowe quotes Roszak (1973) among respected scientists, as giving value based "feeling type of knowledge" legitimation in his proposition that the normal image of science and the model science, should be seen as the value-driven ecological sciences and not the instrumental high-energy physics.

We have therefore investigated, so far as data is readily available, the **profile** of the survey disciplines in relation to their reported structure and content as published in Calendars and Handbooks, and have cross-related this to the statistical data showing the pattern of female:male enrolments in each discipline. A positive relationship has emerged, that is, the more the discipline is described as applied and not theoretical, vocationally-oriented and not curiosity-driven and is structured into a tight, compulsory non-negotiable degree, the lower the female enrolment. This may well be partly because women are not attracted, but partly also because males are more competitive for these degrees precisely because they are described as job-related.

Teaching style is also relevant. The research literature is also ambivalent on how far there is, or is not, a general sex-differential in male and female teaching styles. On balance, the evidence suggests that more males prefer to teach in a directive, information transmitting style and more females prefer a student-oriented, discursive style. Welch and Lawrenz (1982), for example, looked at characteristics of male and female science teachers randomly selected from a fourteen State region of the USA, and reported that the female teachers were also higher on measures of interest in science (intrinsic motivation) and receptivity to change, while more males scored more highly on science knowledge. There are other such studies. (One could hypothesise that only the very interested women survive the barriers to training as a science teacher in a perceptually male domain, of course.)

In higher education, Gaff and Wilson (1971a) postulate that natural scientists are, per se, less student-centred and less permissive towards students than social scientists; and more conservative and less willing to tolerate nonconformist behaviour. This cannot wholly be explained by size of department (eg that very large classes may dictate more inflexible methods), since in the Gaff, Crombag and Chang (1976) study, law and medicine were larger than chemistry but were still relatively more personal, and psychology had a more disadvantageous staffing ratio than chemistry (12:1 compared with 7:1) but was more student-centred. Their (1971a) study of Professors in a wide variety of disciplines showed that the least discursive were in mathematics and engineering, who self-rated items like "discuss points of view other than my own", "relate the course work to other fields of study" and "encourage students to discuss issues which go beyond class reading", the lowest of all disciplines surveyed. This has been held to be because the knowledge-base in maths and the natural sciences is the most highly codified and systematised in analytical and instrumental terms. Thus there is, arguably, a cause-and-effect relationship between the structure of a subject and the teaching style adopted by most academics in that field. In the same study, mathematics and engineering were the disciplines where student-centred teaching approaches were least used. Gaff and Wilson's (1971) data support the theory that the prior imposition of highly codified knowledge is highly correlated with lecturer-domination of teaching and learning styles. Another possible interpretation is, of course, that it is, in the first place, those who prefer an authoritarian and directional style with relatively little "negotiation" involved, who are attracted to the neatness and codified nature of certain of the scientific and technological disciplines in the first place.

It should be noted that theories which set out to explain human behaviour patterns **will never account for all individuals in the groups studied** and will always be subject to exceptions. (Often these exceptions can still be explained in the terms of the theory, however.) Given the reassuring persistence of human individuality in inherited temperament and social variables like class and parental attitudes, there will always be some girls and some boys who do not conform to the sex-stereotyped norms of expected behaviour set by both adults and peer groups in a highly socialised and standardised schooling system. But research evidence in western industrialised countries over several decades, whether from major longitudinal studies like the British Child Development Study (Davie, Butler and Goldstein [1974]) and the Luxembourg Etude Magrip (Institute Pedagogique, 1977), or from a plethora of specific studies focussing on one particular aspect of learning, teaching and socialisation, converge to confirm across social, psychological and cognitive dimensions that

* more girls than boys grow up concerned about the social consequences of their own actions, and of the actions of others;

* more girls than boys value the maintenance of interpersonal relations more than the competitive achievement of future success, if these are seen to be in conflict;

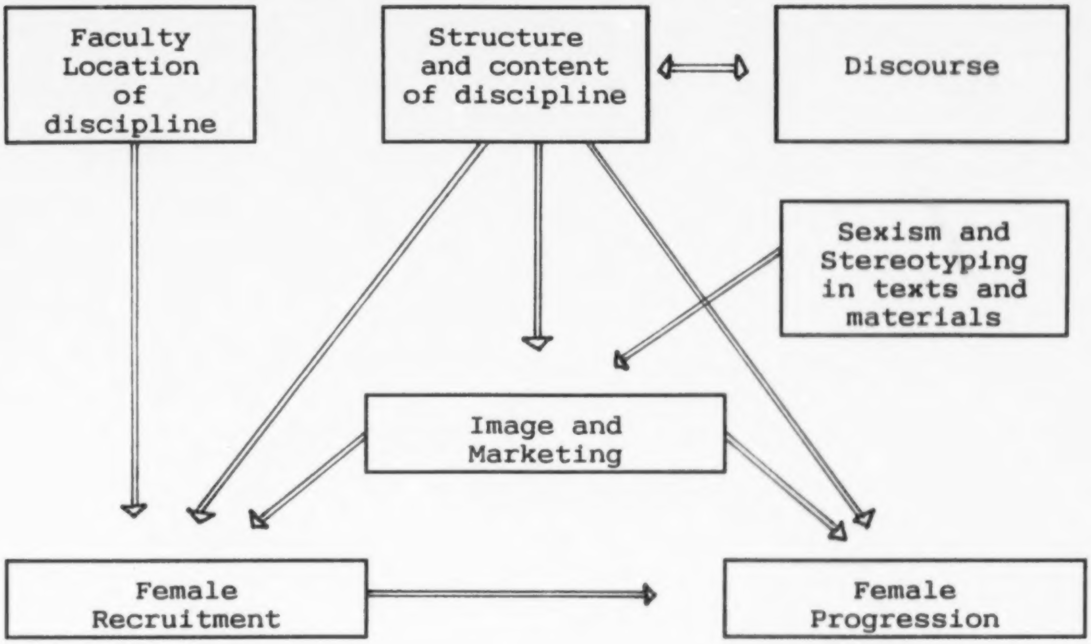
* more girls than boys in adolescence appear to prefer a series of dyadic relationships; more boys than girls work through gangs, groups or sets with common peer-identification goals and motivations;

* more girls than boys use language in discourse which contains negotiating skills, relativities, conditions, value judgements and cues to reach consensus;

* more boys than girls use language as a tool to assert dominance or subordination, to establish rankings in gangs, groups or sets, or to establish territoriality.

We hypothesised that a further cluster of interrelated factors, therefore was influential in the institutional ecology.

CLUSTER (2)


Faculty Location of discipline
Structure and content of discipline
Discourse
Sexism and Stereotyping in texts and materials
Image and Marketing
Female Recruitment
Female Progression

GENDER, LANGUAGE, CULTURE AND INSTITUTIONAL ECOLOGY

We now look at culture, language and discourse as part of a process in which school students entering higher education may experience a mismatch between their previous learning environment and their current one: an ecological mismatch. Moreover, in some circumstances, this mismatch is sex-differentiated according to not only the different environments of, say, single-sex or coeducational schools, but also the conditioning processes of female and male adolescence. The culture, language and discourse interaction in these contexts is seen as contributing to a mismatch process in which more female students than male students need to expend initial energy (mental and psychological) in adapting to new forms of discourse or culture in scientific and technological disciplines, alien to their previous experience and conditioning instead of being able to use the energy for immediate intellectual growth. That is, by the "time-lag" analogy we described earlier, the average (as distinct from gifted pioneer) female student will need longer to adapt and more help in doing so.

Hawley, in his early work on human ecology, implicitly recognises this when he writes that "culture is nothing more than a way of referring to the prevailing techniques by which a population maintains itself in its habitat" (Hawley, 1944, p.404). We argue that these prevailing techniques maintained by the existing (and therefore male-dominated scientific community) involve the language and style of teaching and peer discourse as well as the structure and content of disciplines, and that these differ firstly as between Arts and Sciences, and secondly as between predominantly male and predominantly female environments. Indeed, it will be recalled that at much the same time that Hawley was developing his later ecological conceptualisation, C.P. Snow was arguing that the scientific disciplines and the literary disciplines in Academe were sufficiently different in construction, delivery and ethos as to constitute "two cultures ... with little in common in intellectual, moral and psychological climate" (Snow, 1959, p.2). It is now recognised some decades later that this is not unlinked to the quite different prevailing sex-balance in these two areas of studies.

(i) The Construction and Reproduction of Knowledge-Based Culture: A Male Model

Among sociologists prominent in developing theory on the role of systemic education in reproducing itself in each generation, Bourdieu's work has some immediate relevance to UQ WISTA issues.

In essence, we suggest that the mismatch which Bourdieu highlighted between the prescribing ethos of French higher education institutions and the new clientele of student entrants of the 1960s, has its parallel in the non-adaptability of higher education to a new clientele of women to science and technology in the 1970s. The pioneer women scientists and engineers of earlier decades (at the 5 per cent - 10 per cent level) were untypical high achievers. They had to be, to carve their way in. The more widely-spread female cohorts seeking entrance in the 1970s and 1980s, are arguably not replicas of the pioneer women.

Bourdieu developed a theory of the role of the education system as an agent for reproducing a culture, a code, a set of transmitted values and expectations of behaviour identical with that of the historically inherited elite who control the education system. This work was primarily developed in the context of the lesser ability of working class students to adapt quickly and effectively to the elitism and culturally-mannered middle-class authoritarianism of French lycées and Universities in the 1950s and 1960s. His theory is, however, seen to be highly transferable to the situation of women students entering male-constructed nontraditional disciplines where the women's previous cultural environment, patterns of discourse and peer-relationships also differ from that of the disciplines they are now entering in greater numbers.

Bourdieu sees pedagogy, especially in higher education, as the "imposition of a cultural arbitrary"; arbitrary because the structure and functions of the culture cannot be deduced from any universal principle. It is also inherited unaltered. The cultural arbitrary is in turn endorsed and legitimated by a "*genesis amnesia*" which believes that things have always been as they are, and therefore should continue so. This in turn leads to a "cultural unconscious" in the leadership of education who construct what we learn and how we learn it (Bourdieu and Passeron, 1977, pp.5-9). Bourdieu crystallises this into a term central to his work, a *habitus* (which in its original Latin means a condition, appearance; and philosophically, a moral culture), which, he argues, is "the product of internalisation of the principles of a cultural arbitrary".

Applying this to UQ WISTA, many of the male academics who have traditionally constructed the cultural norms of teaching and learning in science and technology, are apparently unconscious that these disciplines have in fact been constructed on a male norm. Or so we found in the UQ WISTA group interviews with Professors, Deans and Heads of Schools. This, we argue, constitutes a form of *genesis amnesia* and a "cultural unconscious" in Bourdieu's terms. An example of this comes from Margaret Murray. Born in 1863, she was an early student at University College in 1894 and a lecturer in Egyptology by 1899. Trained by Flinders Petrie, she not only consolidated the training of students of anthropology in the early years of the discipline, but her Colonial Indian experience led her to challenge the British Association's Anthropological Section in 1913, urging that it should insist on the government training up women as well as men in some anthropology and sending them out to overseas administration. Her challenge was against Hartland's policy at that time that "anthropology is not a subject for a woman ... I would not allow a woman to come to my lectures", but Dr Haddon supported her on the grounds that

> "it is most important that women should be trained because all we know about the beliefs and customs of the women of these primitive people is what men have told men, and what do they know about it."
> (Murray, 1963)

Yet it has taken the work of the wave of feminist anthropologists in the 1970s to follow through the logic of Haddon's academic and cultural stance of 1913 and to question the male cultural bias of the inherited norms of this discipline.

Bourdieu's own language (even in his original French) is usually difficult, jargonistic and at times dense to the point of near obscurity. When he defines habitus as "the product of history which produces individual and collective practices" (p.82), however, we can recognise the process of institutions reproducing their structures and practices on past models into a definable ecological environment which is then refined into "ethos". A more obscure but central dictum that teaching is the most effective when "the habitus it tends to inculcate approximates the habitus accomplished by all prior pedagogical work and family upbringing" (pp.71-73), can nevertheless be decoded to show that when the teaching content and style and discourse which the inherited cultural base of a University or discipline seeks to transmit, matches more or less the previous teaching and learning experience and family approach to discourse and values of the student entrants, students are most likely to succeed quickly. Among other factors of inherited mismatch to student entrants from different backgrounds from those of previous decades, Bourdieu criticised the dominant use of "le langage magistral" (professorial pedagogical language) which included style as well as language, as alienating to working class students. We are arguing that sexist language and characteristically male discourse, can equally alienate women students.

(ii) Sex-Differentiation in Language and Discourse

What evidence do we have of generally applicable sex-differences in language and discourse? There is nothing pedagogically new about our knowledge that the socialisation process of primary and secondary schooling does produce school students who use mainly different styles and characteristics of language and discourse according to their male or female sex. This is a generalisation not universally applicable across the sexes, but is widely held to be valid at least at the two-thirds:one-third ratio.

It needs to be stressed at the outset that language is the tool which we use to architect the behaviour around us, and to determine our interpersonal relationships. That language is our prime tool for social growth, is not a new theory. As long ago as 1848, William Von Humboldt declared that "man (sic) lives with the world about him principally, indeed ... exclusively as language presents it". It was Max Planck, the great scientist, who pointed out that Universities revolve around talk. What has only more belatedly been recognised is that language often presents a different world to girls from that defined for boys. We discuss this in more detail in the context of the merits and demerits of the single-sex versus coeducation controversy; that is, in the context of the learning environment. Here, we record the main elements which we see as one central element in the ecology of learning environments.

Spender's (1980) research-based analysis of what she describes as "man-made language", includes a commentary on *discourse*, which she describes in terms of "the dominant and the muted". Spender (1980) bases her theories, inter alia, on tape-recordings of mixed-sex conversations over a lengthy period, which have been analysed for a number of factors. She argues that in her research samples women were not in fact able to obtain as much space or time in mixed conversation as men (contrary to popular stereotype). Her conclusion from her research analysis is that "women are queried, they are interrupted, their opinions are discounted and their contributions devalued". While Spender tends occasionally in her work to overstate her case with a rather elliptical empirical base, her specific conclusions on discourse are well based on research which was scientifically conducted. Like Bernstein, Spender does not argue the complete universality of her argument, but uses its general transferability to reconceptualise our approach to discourse. Thus far, the work is both sound and useful and has provided an important breakthrough in our understanding. (There is no short cut to understanding this issue, however, without reading the full text.) There is little doubt that Spender's claim that *"women cannot have equal access to discourse undisturbed"* has been validated not only in her own research, but subsequently in further fieldwork, discussed in a later Chapter in more detail.

At much the same period, Goodwin's (1980) work with American children also confirmed that the organisation of tasks differs considerably when undertaken by groups of all boys and of all girls respectively, and that this is reflected in the language and discourse used in order to establish roles in completing the tasks. "Among the boys the coordinating of such tasks is handled through hierarchical organisation. This type of organisation is uncommon in girls' games generally, and in accomplishing a task activity ... all (girls) participate jointly in decision making with minimal negotiation of status" (p.165). This consensual approach by girls remains increasingly more characteristic of female students than of male as they grow through adolescence. Elliott's (1974) work on sex roles in discussion in classrooms in the early 1970s similarly confirms that there are, at school level, "sex role constraints on freedom of discussion in the small (mixed) group ... such constraints were a major obstacle to any kind of radical innovation in teaching and learning" (p.147). A wider research literature generally identifies discourse in later adolescence and young adulthood as reflecting *power* relations for more males than females, and *interpersonal* relations for more females than males.

This kind of sex-differentiation is confirmed in a different mode by new research by Carol Gilligan whose (1982) published research In a Different Voice has joined the ranks of seminal books making an immediate and diversified impact on relevant theory. Carol Gilligan writes of men and women as having "two ways of speaking about moral problems, two modes of describing the relationship between other and self", and traces the differences "as a contrapuntal theme woven into the cycle of life" (Gilligan, 1982). Women, she alleges, speak and discourse "in a different voice ... characterized not by gender but theme". The "female" theme is described in Gilligan's analysis of interviews as being more concerned with balancing ethics, moral standpoints and human relationships; the "male" with balancing a different moral framework with sharper, more polarised decisions. Her research set in America in the late 1970s does not, however, assert absolutes.

The contrasts between male and female "voices", or messages, interpretations, themes, rather "highlight a distinction between two modes of thought and focus a problem of interpretation rather than represent a generalisation about either sex" (p.2). But her conclusions seem particularly relevant to the issues discussed also in later Chapters, that different disciplines are respectively male-dominated or female-dominated according to the degree to which their construction and image is "socially-responsible".

Gilligan's sample of women described their identity consistently as "defined in a context of relationship and judged by a *standard of responsibility and care*" (p.160). Her male interviewees, by contrast, had a "clearer, more direct, more distinct and sharp-edged" tone of identity. They defined identity more in terms of separation and independence than in terms of attachment. Gilligan suggests that "when women construct the adult domain, the world of relationships emerges and becomes the focus of attention and concern" (p.167). McClelland, writing on power some years earlier, also concluded that "women are more concerned than men with both sides of an interdependent relationship ... are quicker to recognise their own interdependence" (McClelland, 1975, pp.85-86). These different attitudes to dilemmas involving decisions of social and moral responsibility are not far distanced from the sex differences noted in the research showing general differences in girls' and boys' attitudes to the social implications of science.

Gilligan was primarily concerned with the fact that women's message is allegedly different at the level of generalisation (but not universality) as well as the "voice" showing differences of style and constructed reality. The work of Basil Bernstein, which concurrently with that of Bourdieu unpacks different codes of language used by different groups, adds yet another dimension. We should stress that the criticisms that Bernstein's work has aroused in writers like Labov (1970) and others, relate to controversy about how far his conceptualisation of codes is, or is not, class-linked. They do not in any way invalidate Bernstein's basic identification of *different modes and styles of discourse* which he credibly establishes are central factors in the construction of roles and in the transmission of class culture, work culture or subcultures in closely identified groups. It is this central issue of different modes which, when related to gender modes, is relevant to this project.

Bernstein (1971) argues firstly that "forms of socialisation orient the child towards speech codes which control access to relatively context-independent meanings" (p.200). He relates the use of language and of role relationships to four interrelated contexts of socialisation: the regulative (authority), the instructional (transmission of learning), the imaginative or innovating, and the interpersonal. He concludes that "the critical orderings of a culture or subculture are made substantive - are made palpable - through the forms of its linguistic realisations of these four contexts" (p.206), thus supporting the language stance of researchers from Humboldt through Bourdieu to Spender. Of these four contexts, there is solid research evidence that at least three are sex-differentiated at the school level (from the conditioning process in schooling, *not* by any innate biological determinism), viz language and authority, language of instruction and the presence or absence of interpersonal (as distinct from group or objective) elements in discourse. They are also gender-differentiated in so far as the scientific and technological disciplines are structured on a discourse redolent more of authority than of the imaginative or the interpersonal interface of facts and beliefs.

Bernstein argued that discourse takes place in two modes, the restricted code and the elaborated code. The former has a style which is functional, ritualistic and fairly standardised, as described. It is also more directional and authoritarian. The conversational exchange "presupposes a shared cultural heritage ... (and) ... closely shared identifications and expectations" (p.149). The further implication of the research of Spender and Gilligan is that this restricted code style is characteristic of more young males than young females (of any social class). The elaborated code involves more conditionals and subjunctives and (in terms of content) more negotiation, probability, assumption, and is modified in the light of the special attributes and context of the listener (p.150). Spender, Gilligan and others describe this as characteristic of more females than males. Bernstein points up the difference as inducing "a sensitivity to the implications of separateness and differences", a sensitivity found by many researchers to be more characteristically "female".

Relevant to UQ WISTA issues is Bernstein's theory that the elaborated code (which all higher education students must have acquired by definition, by then) itself operates through two modes: elaboration of interpersonal relations and elaboration of relations between objects. Bernstein comments that "an individual going into the arts is likely to possess an elaborated code oriented to the person; whilst an individual going into the sciences, particularly the applied sciences, is likely to possess an elaborated code oriented to object relations" (p.156). This, of course, can be matched with the female domination of arts and male domination of sciences, reinforcing the socialised antithesis of personal versus objective. Again, we would argue that most of those girls who have so far entered the physical sciences, have been those who already conform to the restricted-code style of communication, and to the object-relations style of the elaborated code: those nearer the male norm. And in this regard, we note yet another potential element of the match:mismatch issue of the transfer of school female students into higher education male-dominated learning environments. How like the typical male student in discourse and value or interest base, are the majority of aspiring female science and engineering students?

If their discourse style is in fact generally different from that of peer group males (and research in language and gender suggests that it is), the adaptation process and our time-lag phase become areas for policy intervention.

Any readers who doubt, moreover, that the dominant discourse style in higher education in the scientific and technological disciplines, is based on a male-as-norm paradigm, may wish to note that Bernstein's (1971) work is important as a frame of reference not in any way because he suggests any sex-differentiation in modes of discourse in young people. He could not, since in common with most sociological researchers in the 1960s, he restricted his empirical samples to young males - ***precisely the "male-as-norm" syndrome we have criticised.*** His research is mainly based on empirical work with young male students on day release at a London College of Further Education. At no stage in his challenging detailed writings do we learn of an attempt to match his early works on males with a parallel study of young females to check their discourse patterns. His control group consisted of elite boys from an English Public School. Similarly, the seminal work of Liam Hudson (1966, 1968 and 1970), looking at arts and science specialisations in the context of converger and diverger gifted students, which in turn led to an important further study of creativity and connections in learning, was based exclusively on schoolboys only, and on the perceptions and self perceptions in language, learning and motivation of male adolescents.

IMPLICATIONS

We discuss further in the last two Chapters, the inter-connectedness of institutional factors, image, environment, discourse and peer attitudes to retention and dropout in particular. At this stage, it is useful to summarise some immediate implications for policymakers.

- Statistical data and substantive research from a range of disciplines, justify a paradigm shift from blaming girls and women in a deficiency-context for the non-recruitment to certain scientific and technological disciplines, to re-examining the learning environment of disciplines and institutions to meet the needs of a wider clientele.

- Some scientific and technological disciplines are more prone to *genesis amnesia* and to non-adaptability to new clienteles than others (*vide* sharp interinstitutional and interdisciplinary differences).

- The concept, characteristics and influence of critical mass needs further examination in the context of moving the image and sex-balance of disciplines from nontraditionality to sexnormality for females (in the eyes of males as well as females).

- Institutional ecology can be measured by clusters of interrelated factors; two such clusters have been identified in this Chapter.

To illustrate the vividness of the real-life application of our construction of the match:mismatch difficulty of minority females becoming integrated into male higher education disciplines, we quote from a study of graduates of the first coeducational class at America's West Point Military Academy. The researcher was investigating the *mentor* role (if any) of the new second year (sophomore) women towards the new first year (freshmen) women students, and noting their failure to support those behind them. Yoder et al (1982) wrote:

> *"the major difference between these two groups was the hard-earned yet marginal and constantly questioned peer acceptance (which) the sophomore women had won from the dominant male group."*

We return to the issue of peer attitudes in the penultimate Chapter. But roles in higher education learning processes are dictated by Professors and lecturers as well as by peer group fellow students. Bourdieu's *genesis amnesia* is matched by the institutional inertia of which many analysts write. Hannan and Freeman (1977), for example, suggest that organisations eschew adaptation to new demands or to new entrants because "there are a number of processes that generate structural inertia" (p.930), in which they include internal political constraints ("when organisations alter structure, political equilibria are disturbed", p.931).

We next look at where women, students and staff are, and are not, in our survey institutions.

REFERENCES

Bernstein, Basil (1971) **Class, Codes and Control**, Routledge and Kegan Paul, London.

Bourdieu, Pierre and Passeron, Jean-Claude (1977) **Reproduction in Education, Society and Culture**, Sage Publications, London.

Bourdieu, Pierre (1985) "The social space and the genesis of groups" in **Theory and Society**, 14, 6, 1985.

Bourdieu, Pierre (1986) **Distinction: A Social Critique of the Judgement of Taste**, Routledge and Kegan Paul, London.

Byrne, Eileen M. (1985) **Women and Engineering: A Comparative Overview of New Initiatives**, Bureau of Labour Market Research, AGPS, Canberra.

Cameron, Kim (1984) "Organisational Adaptation and Higher Education" in **Journal of Higher Education**, Vol.55, No.2, pp.122-144.

Davie, R., Butler, J. and Goldstein, H. (1974) **From Birth to Seven**, Longman, London.

Duncan, O.D. (1959) "Human Ecology and Population Studies" in **The Study of Population**, Hauser, P. and Duncan, O.D. (Edits), University of Chicago Press.

Elliott, John (1974) "Sex Role Constraints on Freedom of Discussion: A neglected reality of the Classroom" in **New Era**, Vol.55, No.6, 1974, pp.147-155.

Elton, C. (1927) **Animal Ecology**, Sidgwick and Jackson, London.

Gaff, J.G. and Wilson, R.C., (1971) "Faculty Cultures and Interdisciplinary Study" in **Journal of Higher Education**, March 1971, pp.186-201.

Gaff, J.G., Crombag, H.F.M. and Chang, T.M. (1976) "Environments for Learning in a Dutch University" in **Higher Education**, 5, 1976, pp.285-299.

Gilligan, Carol (1982) **In a Different Voice**, Harvard University Press, Cambridge, Mass.

Goodwin, M.H. (1980) "Directive-Response Speech Sequences in Boys' and Girls' Task Activities" in **Women in Language and Literature in Society**, (Edits) McConnell, G.S. et al, Praeger, NY.

Gould, Rosemary (1976) "The Ecology of Educational Settings" in **Educational Administration**, Vol.4, No.21, Spring 1976, pp.14-27.

Hannan, T. and Freeman, J. (1977) "The Population Ecology of Organisations" in **American Journal of Sociology**, Vol.82, No.5, May 1977, pp.929-964.

Hawley, Amos H. (1944) "Ecology and Human Ecology" in **Social Forces**, No.22, May 1944, pp.398-405.

Hawley, A.H. (1950) **Human Ecology: A Theory of Community Structure**, Ronald Press, NY.

Hawley, Amos H. (1968) "Human Ecology" in **International Encyclopaedia of the Social Sciences**, (Edit. David Stills), Vol.4, Macmillan, NY, and The Free Press, pp.328-337.

Hudson, Liam (Edit)(1970) **The Ecology of Human Intelligence**, Penguin Modern Sociology, Penguin Books, Harmondsworth.

Hudson, Liam (1966) **Contrary Imaginations: A Psychological Study of the English Schoolboy**, Pelican Books, Penguin, Harmondsworth.

Hudson, Liam (1968) **Frames of Mind: Ability, Perception and Self-Perception in the Arts and Sciences**, Methuen, London; later in Pelican Books, Penguin, Harmondsworth, 1970.

Institute Pedagogique (1977) **L'Etude Magrip**, Luxembourg.

Jackson, B. and Marsden, D. (1962) **Education and the Working Class**, Routledge and Kegan Paul, London.

Jawetz, E., Melnick, J. and Adelberg, E. (1984) **Review of Medical Microbiology**, Lange Medical Publications, Los Altos, Ca., 16th Edition.

Labov, W. (1970) "The Logic of Non-Standard English" in **Language and Poverty**, (Edit) Williams, F., Markham Press.

Lowe, Philip and Worboys, Michael (1980) "Ecology and Ideology" in **The Rural Sociology of the Advanced Societies: Critical Perspectives**, (Edits) Buttell, F.H. and Newby, H., Croom Helm, London, pp.433-452.

McClelland, David C. (1975) **Power: the Inner Experience**, Irvington, NY.

Murray, Margaret (1963) **My First Hundred Years**, William Kimber, London.

Schuh, J.A. and Allen, M.R. (1978) "Implementing the Ecosystem Model" in **Journal of College Student Personnel**, March 1978.

Snow, C.P. (1959) **The Two Cultures and the Scientific Revolution**, Cambridge University Press.

Steele, F.(1975) **Physical Settings and Organisational Development**, Addison-Wesley, Mass.

Stern, G.S. (1970) **People in Context: Measuring Person-Environment Congruence in Education and Industry**, John Wiley and Sons, NY.

Van Demark, Paul and Batzing, Barry (1987) **The Microbes: An Introduction to their Nature and Importance**, Benjamin Cummings Publishing Co. Inc., Ca.

Wakeford, Richard (1984) "The Medical School Learning Mileu, A Study of Students' Perceptions of Twenty-five British and Irish Medical Schools", in **Studies in Higher Education**, Vol.9, No.2, pp.139-149.

WICHE (1973) **The Ecosystem Model: Designing Campus Environments**, Western Interstate Commission for Higher Education, Boulder, Colorado.

Yoder, Janice et al (1982) "Mentors: a debt due from present to future generations", paper presented to the **Annual Convention of the American Psychological Association**, 23-27 August 1982.

CHAPTER IV

WHERE WOMEN ARE, AND WHERE THEY AREN'T: INSTITUTIONAL AND DISCIPLINARY DIFFERENCES

"Women hold up half the sky"
(Chinese Proverb)

"You gave me wings to fly;
Then took away the sky."
Leonora Speyer,
Fiddler's Farewell, 1926

This Chapter discusses the statistical data from the survey of five Universities and five Institutes of Technology, in the specific context of some of the revised theory and concepts set out in earlier Chapters. In particular, we have looked at the statistical patterns against a recognition that women and girls still appear to have a territorially limited flight path and a "glass ceiling" on their academic flights, despite their increasing achievements at Grade 12.

One of the central issues being explored in the University of Queensland WISTA project has been the environmental "fit" of the scientific and technological disciplines to the students who enter them. We have argued earlier that disciplines acquire "male" or "female" or allegedly sexneutral labels, images and perceived styles. We have also argued that how far women either are expected to conform to the male norm, or are enabled to behave in a way that fits their own self-perception, can affect both their access to and their retention and progression in different disciplines. A statistical analysis of the actual sexbalance at each level of each discipline in the ten survey institutions is thus a major element in the construction of different discipline "profiles" on the one hand, and in the assessment of the male or female domination or alleged sexneutrality, on the other. We have looked in particular at the patterns of women's participation both at staff and student level, in relation to several factors and dimensions set out in the theoretical framework in Chapter I.

We have examined a range of statistical data against four particular dimensions.

(a) Ecology and Critical Mass

One objective was to establish the actual male:female balance in the institutions as a whole, in the undergraduate sector and various postgraduate sectors in the relevant disciplines. It is a reasonable hypothesis that the image of an institution will be seen as male-dominated or as relatively sexneutral, in relation to the actual overall enrolments in the whole

University or Institute. Similarly, the possible environmental impact on women students (especially those from single-sex girls' schools, from small schools and/or from rural schools) of the fact that three out of four or two out of three of all students walking around the campus are men, is relevant to our theories of the adaptation process needed by women students in their critical first year. This was the case for several Institutes and one of the Universities in our survey.

We also wished to test out for critical mass at the most basic level in relation to the overall numbers in each sector and in each discipline. In which disciplines and levels was there at least first level data which might support critical mass theory?

(b) Discipline Profiles

A fundamental element in the UQ WISTA project is our focus on why different disciplines within an area of science and technology, recruit so differently. If, for example, it is *only* a question of image or a marketing question, why are not the recruitment levels for each discipline and level *constant* across institutions? But they are not. We hypothesised that we would find some patterns which were consistent across most institutions but which showed idiosyncrasies in one or two Universities or Institutes which might enable us to explore further diagnostic questions about other factors (eg mentorship, the structure of the discipline, the attitudes of Deans or Heads).

(c) Nontraditionality, Sexnormality and Sexneutrality

A subdivision of this angle is the perception by school students and teachers in the schooling system that some disciplines carry male labels or that others are sexnormal or sexneutral for either sex. Our early research reviews convinced the researchers that peer group attitudes and adult/teacher attitudes are key determinants of adolescent subject and vocational choice. It followed that we needed to look further at the actual, as well as the perceived "maleness" or "femaleness" of each survey discipline.

(d) Progression to Postgraduate Study

In view of the almost universal problem of women's disproportionately lower proportion of enrolments at each of the postgraduate levels, we clearly wished to establish whether there were discipline differences in retention, progression etc and if so, where and why. One of several things might be true. Our disciplines may show consistent common cascading losses, thus suggesting that the problems of critical filter relate mainly or wholly to broader institutional, social or psychological factors. Alternatively, we may find that some disciplines show markedly ***different patterns as between disciplines but reasonably***

constantly across institutions, which require explanation related to the nature of the construction of the area of study, or to its vocational possibilities, or to the degree of its male or socially responsible image. Or, alternatively, we might find reasonably constant patterns but ***divergences within discipline patterns at only one or two institutions***, suggesting the specific influence there of institutional ecology and/or influence of individual Deans and Heads of Schools (eg in marketing, in mentorship of women, etc).

The interpretations and discussion which follows should be seen against the contextual explanations given earlier in this report.

THE STATISTICAL DATA: PATTERNS AND INFERENCES

We now look at the institutional and discipline patterns against the four concepts or dimensions outlined above which form a central part of our theoretical framework.

In the section that follows, the data analysed is mainly for the survey's base year of 1985, moderated or reinforced if necessary by 1986 figures. For this reason, we have frequently looked separately at the five Universities and the five Institutes as such. We remind that since 1986, all of the Institutes have been redesignated as Universities under the Dawkin reorganisation of higher education, notionally (and cosmetically) abolishing the Binary System. But the sexbalance of their student and staff cohorts, their physical environment, their Faculty and degree structures and their ethos and culture have not, of course, changed with equal overnight speed. We therefore adhere in our analysis, to their status as at the time of the survey.

We do not yet know enough about the actual impact on different kinds of minorities of the domination of their ecological niche or their ecosystem in education, teaching and learning by a principal sex, race or cultural identity. It is, however, reasonable to hypothesise that the better the balance, the more a feeling of normality is achievable. The more the imbalance, the more likely a cultural mismatch will occur requiring "time-lag adaptation".

Interinstitutional Differences

If we first look at the overall picture nationally and in our survey institutions, we see sharp sector-differentiation, and differentiation between institutions.

Women as % of all Enrolments: Australia 1985

	Universities %	Advanced Education %
All enrolments	45.8	49.1
Masters	36.4	22.1
PhD	28.7	-

We believe that the actual overall climate of a University and an Institute respectively, is bound to be affected by the extent to which women are or are not a critical mass of the whole. Within that concept, their relative actual proportion of a discipline, level of study, institution as a whole will also affect the image that students have as a whole of the nontraditionality, sexnormality or sexneutrality of their direct learning environment.

But even overall female enrolments in the five Universities did not reach parity with males in any institution. Within these five, the University of New South Wales had the lowest overall female percentage, although above the probable threshold of critical mass; other Universities ranged from 42 per cent to 48 per cent. That is, two were above and three below the national average in the survey years:

TABLE IV(1)

ALL STUDENTS

Universities	1985 T	 F %T	1986 T	 F %T
University of NSW	17,226	36.3%	18,989	36.0%
University of Qld	17,948	47.5%	18,339	48.4%
Monash University	13,586	47.7%	13,839	48.1%
University of Adelaide	9,022	42.1%	8,694	42.8%
University of WA	9,512	44.1%	9.512	45.5%
Total	67,294	43.5%	69,373	43.9%

In terms of image and ecology, in four out of five of the Universities, women students were well over the "sex-neutral" critical mass of 40 per cent (but only two approached half). The exception (UNSW) is a former Institute of Technology. In environmental terms, the general perception will be that approaching 1 in 2 (1 in 3 at UNSW) of all students on campus are women.

When we look at the five Institutes, the sex-imbalance (overall critical mass) is even more marked.

TABLE IV(2)

Institutes	1985		1986	
	T	F %T	T	F %T
NSWIT	8,673	27.9%	9,435	30.6%
QIT	8,493	27.6%	8,935	29.2%
RMIT	10,875	34.3%	11,163	35.8%
SAIT	6,747	34.7%	6,971	36.5%
WAIT	12,022	42.9%	12,586	44.6%
Total	46,810	34.2%	49,090	36.0%

At the Institutes, only one (WAIT) recruited over 40 per cent of its student body from women. Of the remainder, only 1 in 3 students were female at RMIT and SAIT; only just over 1 in 4 at NSWIT and QIT. At the most general of levels, the image impact at the Institutes was one of continuing male-domination of the overall student body. Even the overall environment in terms of critical mass will remain one of non-traditionality for women while these proportions persist.

Within all ten survey institutions, however, the pattern changes when the overall student body is further divided by level of study. Three out of four postgraduate students are still male at most institutions. But here, *inter-institutional* differences become much more sharply marked.

If we rank the institutions in an ordinal sequence according to the percentage of women students at each institution, the top five at each level emerge as follows:

TABLE IV(3)

Women students (1985) as a percentage of:

All students in institution		All undergrads		Masters (research only		PhD		Other P/G	
U of Q	48	U of Q	50	Mon	41	Mon	33	Mon	60
Mon	48	Mon	49	UWA	40	U of A	30	UWA	55
UWA	44	UWA	46	U of A	35	U of Q	27	U of Q	46
WAIT	43	WAIT	45	U of Q	31	UNSW	26	SAIT	44
U of A	42	U of A	43	UNSW	30	UWA	25	UNSW	37

Institutes, of course, do not offer Doctoral programmes and this table omits masters degrees by coursework. But the pattern which emerges suggests that it is not only a question of critical mass relationships. We cannot yet draw easy conclusions why the two highest female PhD enrolments occur in the institutions with, respectively, one of the highest and the lowest undergraduate female enrolments, without looking further at other factors of institutional ecology, and specifically at the mentor role in higher education. It is not an adequate explanation, moreover, to point to Monash University's higher than average overseas enrolment in postgraduate degrees in the 1980s. This would not alone explain why overseas countries not particularly generally or culturally supportive to women's advancement, send their women potential engineers or scientists to Monash University more frequently than elsewhere. The University of Adelaide had the lowest female enrolment overall and at undergraduate level, but a higher than average PhD enrolment. It is more likely that factors related to specific disciplines and to institutional supportiveness or otherwise, affected these patterns.

Table IV(4) on page 84(a) gives more detail of the overall percentages of women postgraduate students by level for 1985 and 1986. Given a widespread tendency among higher education academics to lay the accountability for girls' under-recruitment to science and technology at the feet of the schools, the careers advisers, the preschools, the parents (but to defend higher education as altruistically sex-neutral and gender-unbiassed), the patterns illustrated in Table IV(4) and in later tables need much more explanation. It is difficult, for example, to write off these wide inter-institutional variations in female enrolments as due to such generic factors as marital status (*"women leave to get married and have babies"*) or the job market (*"women don't go on in geology or surveying because they can't get jobs"*) or, even more blandly, social attitudes (*"it's all a matter of society's perceptions, we can't alter those"*).

If these were the *major* influence, there is no reason why they should affect one University or Institute proportionately and consistently more, or less, than another comparable institution. This Report argues that there are idiosyncratic institutional factors which are more influential. One hypothesis to explain the differential patterns of Table IV(4) is that the higher level of **critical mass** of women in the overall student environment in some institutions has created a more gender-neutral or sex-normal environment for *progression* (as distinct from access). A second hypothesis (not necessarily mutually exclusive) is that proportionately more Deans and Heads of Schools in Monash, UWA and University of Adelaide (the three with the highest 1985 masters research and PhD female percentages of enrolments) may have accepted the **mentor** role not only as a normal part of their work, but as a particular responsibility towards women students, an issue discussed in the two succeeding Chapters.

If we relate Tables IV(1) and (2) on the one hand to Tables IV(3) and IV(4) on the other, it is evident that critical mass *alone* will not achieve equal recruitment at postgraduate level; but that it appears to be a contributory factor. On the one hand, the institutions with higher undergraduate enrolments did generally have higher postgraduate enrolments

TABLE IV (4)

ALL POSTGRADUATE STUDENTS BY SEX AND INSTITUTION

	1985								1986							
	Masters Coursework		Masters Res. & Thesis		Ph.D		Other Postgrad.		Masters Coursework		Masters Res.& Thesis		Ph.D.		Other Postgrad.	
	T	F%T	T	F%T	T	F%T	T	F%T	T	F%T	T	F%T	T	F%T	T	F%T
University of NSW	1944	32.4%	501	30.0%	776	25.9%	359	36.5%	2116	34.0%	534	27.0%	863	26.0%	450	38.0%
NSWIT	317	8.8%	97	25.8%			524	30.3%	339	13.6%	104	24.0%			613	28.1%
Uni of Qld	1010	36.7%	479	30.9%	864	27.4%	1574	45.5%	1019	39.6%	472	32.4%	872	27.3%	1604	46.2%
QIT	61	14.8%	50	8.0%			635	31.7%	99	20.2%	68	8.8%			674	32.3%
Monash	1026	36.8%	610	40.5%	654	33.5%	956	60.4%	1084	38.7%	620	41.8%	668	34.6%	962	62.3%
RMIT	287	7.3%	110	10.0%			962	36.3%	350	9.4%	158	15.8%			1049	35.6%
Uni of Adelaide	325	29.8%	333	35.1%	504	29.8%	360	41.1%	371	33.7%	341	36.1%	455	30.3%	379	45.9%
SAIT	104	17.3%	84	14.3%			956	43.7%	98	18.4%	96	13.5%			1044	49.6%
Uni of WA	494	25.0%	399	40.0%	455	25.0%	776	55.0%	507	36.8%	432	40.5%	467	26.3%	497	55.7%
WAIT			*357	27.0%			1705	34.0%	72	32.4%	192	22.9%			1870	36.8%
TOTALS	5568	30.1%	3020	32.1%	3253	28.3%	8807	42.1%	6055	32.9%	3017	32.1%	3325	28.7%	9142	43.0%

* Masters figures at WAIT not subdivided between coursework and thesis.

and UNSW, for example, also had lower undergraduate (and lower postgraduate enrolments in the University group). But some interinstitutional differences still skewed an overall emerging pattern, and need further explanation. The University of Queensland, for example, had the highest female undergraduate enrolment but a relatively low masters research percentage and an average female PhD enrolment. By contrast, the University of Adelaide had a relatively lower (43 per cent) female undergraduate enrolment, but a proportionately higher female PhD enrolment.

Inter-institutional variations are equally marked in relation to women staff. Nationally, women academics were fewer than one-fifth of full-time academic staff in Universities and fewer than one-third in CAEs/Institutes, in 1985. But they were only one-sixth of teaching-and-research staff.

TABLE IV(5)

AUSTRALIA

Women as % of FTE Academic Staff, 1985

	Universities	Adv. Education
All full-time staff (FTE)	19.8	28.1
Full-time equivalent teaching-and-research	17.5	-
Full-time equivalent research only	30.0	-

Table IV(6) on page 85(a) gives the percentage of female academic staff in the institutions as a whole. The trend is towards marginal increase over the three years, but even as at 1987, in nine out of ten institutions women were fewer than one-quarter of all full-time academic staff, and in two institutions, were fewer than one-fifth. In 1985, our base year, the inter-institutional averages are even more marked: at UNSW and NSWIT and the University of Adelaide, women were only 16 per cent or fewer of all staff; at WAIT and Monash, they were a quarter of full-time staff. Again, one must look to institutional or to discipline-based factors to account for this. Social and generic factors alone are unlikely to produce such high inter-institutional variations.

If we look at the general staffing profiles against the "nontraditionality" scale described in Chapter I, in none of the institutions does the overall proportion of women full-time academic staff reach the critical mass level of 30 per cent or more which would create (hypothetically) an environment of sexneutrality. In all ten institutions, their proportion is such as to create an image of untypicality for girls and women: an overall (male:female) ratio of 3:1 or 4:1

TABLE IV (6)

FEMALE FULLTIME ACADEMIC STAFF AS % OF ALL FULLTIME ACADEMIC STAFF BY INSTITUTION, 1985-1987

Institution	1985		1986		1987	
	No.F	F %Total	No.F	F %Total	No.F	F %Total
University of New South Wales	202	15.0%	220	16.0%	232	17.0%
NSW Institute of Technology	62.9	15.8%	92.4	20.7%	102.1	21.6%
University of Queensland	288	20.7%	289	20.8%	314	22.3%
Qld Institute of Technology	236	21.9%	257	22.0%	270	24.0%
Monash University	266	23.5%	279.2	24.9%	287.3	24.9%
Royal Melb. Institute of Tech.	146.7	22.2%	141.1	21.3%	156.4	22.5%
University of Adelaide	115.2	16.2%	126.7	17.5%	134.9	18.3%
SA Institute of Technology	86	22.1%	85	21.4%	95	23.4%
University of WA	265	22.5%	249.9	21.7%	282	23.8%
WA Institute of Technology	166	24.9%	152.3	24.8%	177.6	27.5%

or 5:1, which adds to the general male-dominated culture of the environment.

We look further at staffing in each discipline profile, and in discussing the role model factor later.

INTERDISCIPLINARY DIFFERENCES

The distinctions become both sharper and yet more complex when we move on to look at individual disciplines and subdisciplines. While some of the foregoing is replicated at discipline level, other patterns and issues also emerge.

The 1985 enrolments for each discipline in each institution have been analysed as divided by sex and level of study. We have analysed these data against the conceptual framework set out in the earlier Chapters, in different ways. We have, for example, looked at the discipline patterns within each institution; and at discipline patterns across all ten institutions. Given that we have suggested that the general perception by students of a discipline as nontraditional, or as sexnormal for women, or as sexneutral, was part of the institutional and discipline-based ecology and was causally related to both access and progression, we have also analysed the disciplines against this theory.

Firstly, Tables IV(1) and IV(2) above, showed the undergraduate female recruitment as a percentage of all undergraduates in the institutions, while Table IV(7) below shows the level of female recruitment to those scientific and technological disciplines included in the survey, as a block.

Table IV(7)

Female Undergraduates as % of Survey Disciplines Averaged Across the Disciplines in each Institution in 1985

	%
UNSW	25.8
UQ	24.2
Monash	29.2
U of Adelaide	27.9
UWA	23.0
NSWIT	20.2
QIT	14.8
RMIT	21.3
SAIT	12.8
WAIT	15.6

Despite the generally gender neutral levels of recruitment at the overall institutional level, only at Monash University did women science and technology undergraduates as a whole approach the critical mass threshold of "sexnormality" at almost 30 per cent. In the Universities, they were about 1 in 4 students, in the Institutes from 1 in 5 (RMIT) to 1 in 8 (SAIT).

Each institution, moreover, shows a different pattern as between disciplines. Some disciplines, for example, recruit consistently not only higher than the average, but higher than the institutional average for science and technology. Other disciplines recruit consistently below the institutional average. Others vary from institution to institution. That is to say that we found that

* **some disciplines (Physics, Engineering) seem almost impervious to institutional factors and recruit uniformly below the science and technology average both across and within their institutions. Causes for female underrecruitment are likely to lie therefore predominantly with the discipline as such and to require fundamental review of such factors as image, marketing, structure, style and content, rather than solely in institutional ecology.**

* **other disciplines (Chemistry, Geology, Mathematics, Computing) recruit much more variably, and show more evidence of potential influence of institutional factors. These disciplines need review at both the institutional ecology and the disciplines levels.**

Diagrammatically, the differences emerge more sharply. Diagram IV(1) on page 87(a) shows the University of Queensland's profile for 1985; diagram IV(2) on page 87(b) that for the (then) Western Australian Institute of Technology.

In the diagrams which follow, it should be noted that the mean percentage of female enrolments is used as the baseline for comparison between disciplines. This is used because it allows comparison of enrolment percentages (ie proportions in the context of critical mass) independently of actual enrolment numbers.

The University of Queensland's female recruitment across the survey disciplines showed a mean of 24 per cent. But it will be seen that some disciplines vary much more acutely from the mean than others, engineering, ***physics*** and computer science being below the mean, but ***chemistry*** well above, at the gender-neutral level.

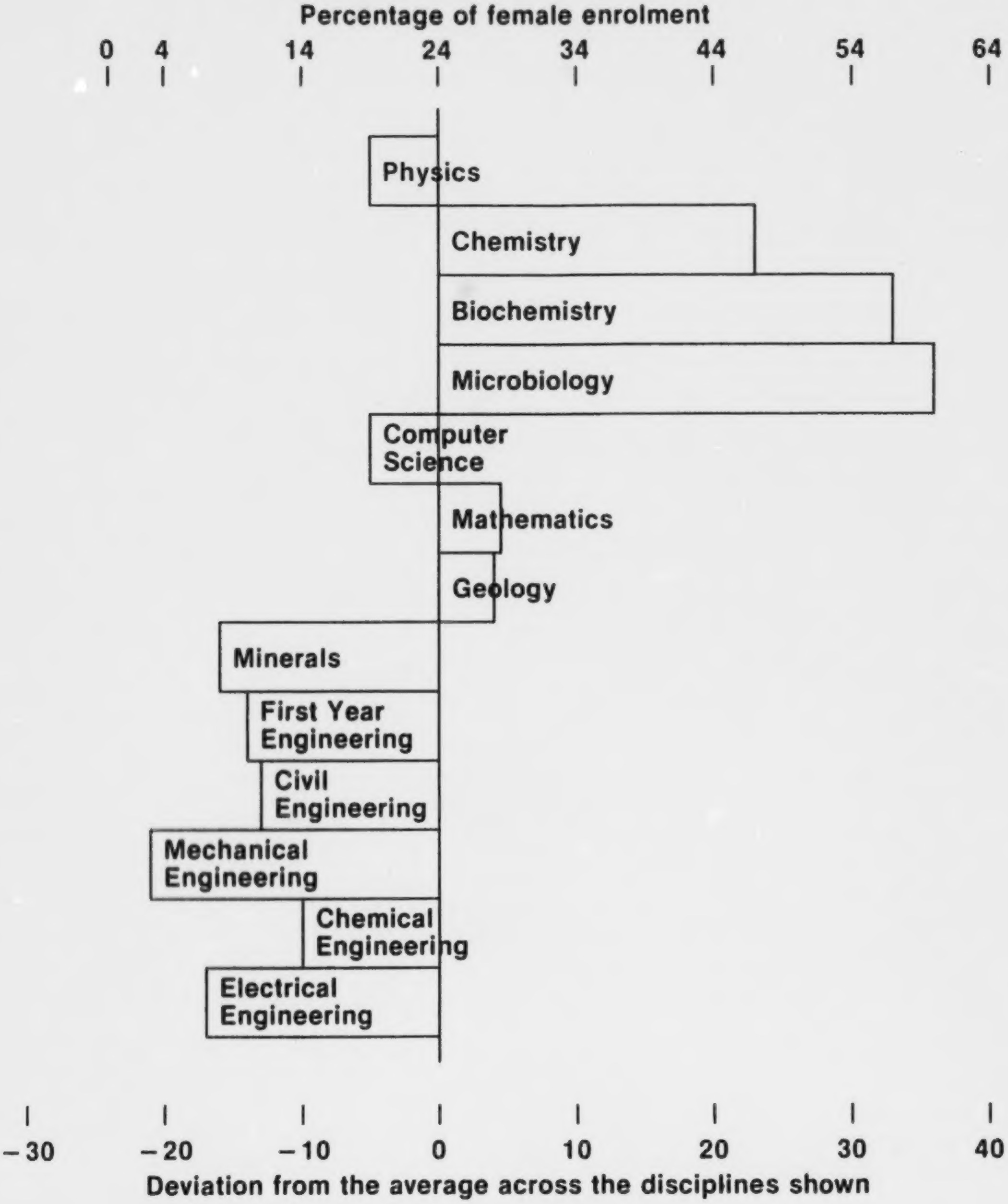
The WAIT Institute profile is less variable and has a mean of only 15.6 per cent compared with the University's 24.4 per cent. The deviation from the Institute's mean, when we exclude biotechnology, falls within 10-15 either way; but that of the University from 20-35 either way.

The profiles for the remaining institutions are illustrated in diagrammatic form at the end of this report.

WISTA

Diagram IV(1)

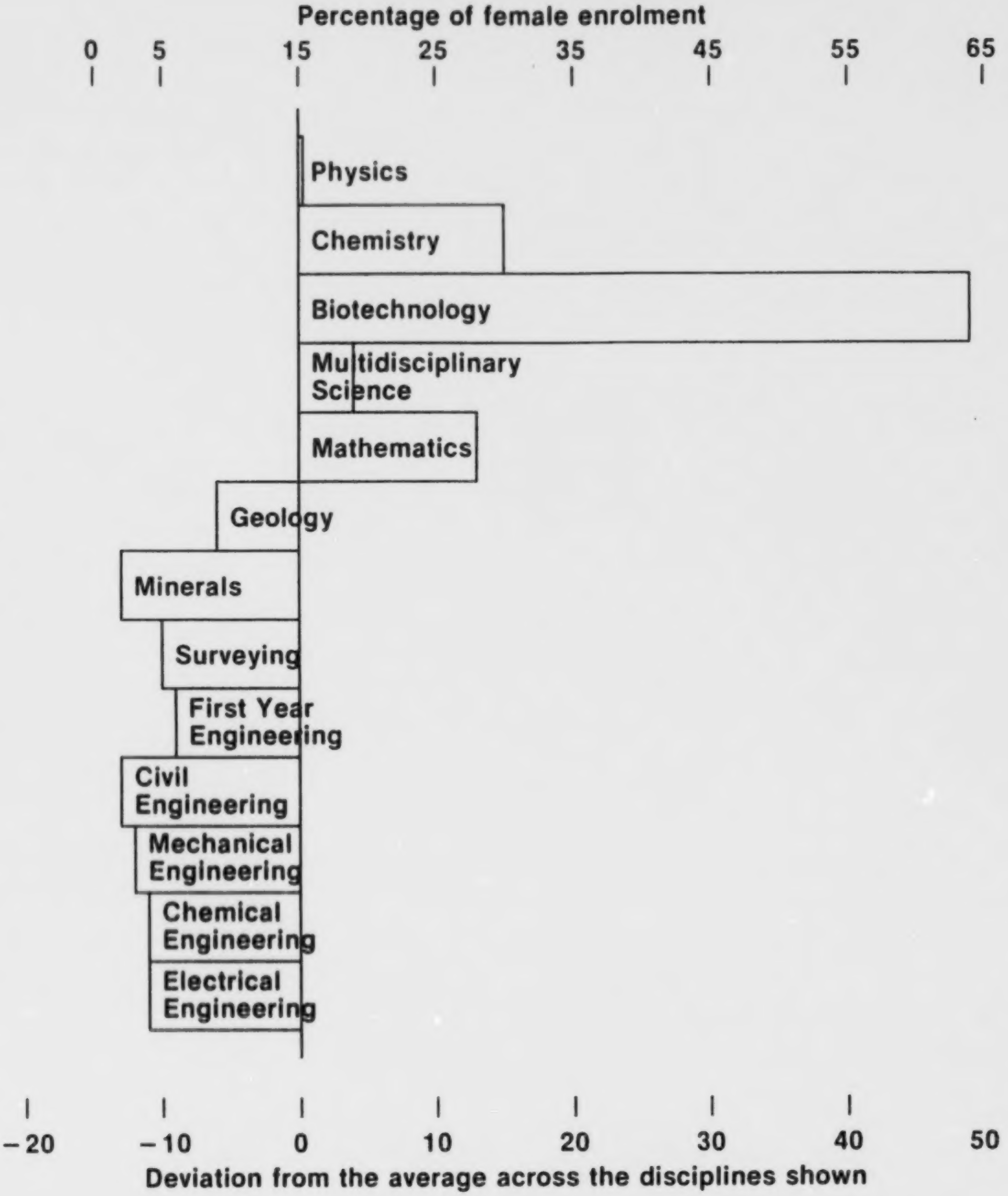
University of Queensland
Undergraduate enrolments in 1985



Notes: 1. *Geology* includes "Geology and Mineralogy".
2. *Minerals* includes "Mining and Metallurgical Engineering".

WISTA Diagram IV(2)

Western Australian Institute of Technology
Undergraduate enrolments in 1985



Notes:
1. *Geology* includes "Geology and Geophysics" and "Mining Geology".
2. *Minerals* includes "Minerals Exploration", "Metallurgy", "Mining and Minerals Engineering".
3. *Surveying* includes "Surveying and Mapping".
4. *Civil Engineering* includes "Building Construction and Civil Engineering".
5. *Electrical Engineering* includes "Electrical Engineering" and "Electronic and Computer Engineering".

We then looked in more detail at each survey discipline. On our first analysis, it became clear that disciplines were divided into three different categories:

- disciplines which show a consistent profile across the ten survey institutions.
- disciplines which show a consistent profile across Universities or across Institutes; but a different profile as between Universities as such and Institutes as such.
- disciplines which show a highly variable pattern both between institutions and between types of institutions.

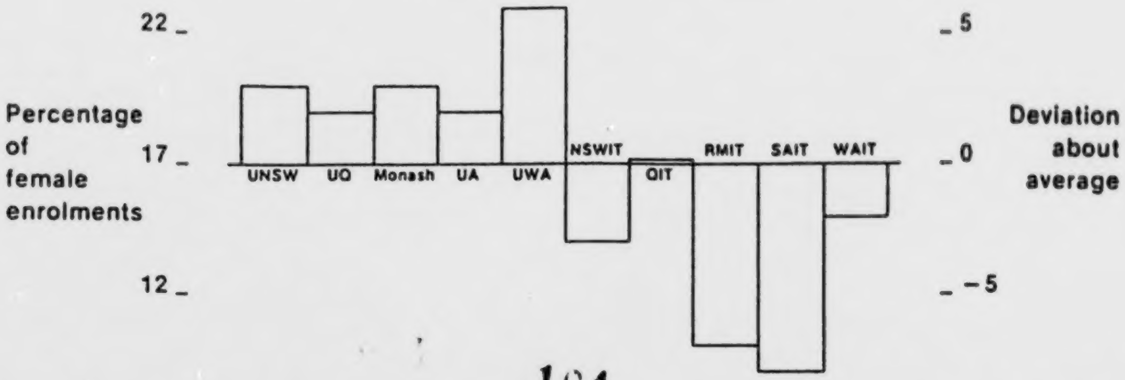
A discipline "**Profile**" has therefore been constructed for each discipline, in addition to the ten institutional profiles in relation to overall female recruitment to the scientific and technological disciplines under survey. We suggest, from the analysis which follows, that in future research, enquiry and affirmative action will need to focus on single disciplines and subdisciplines, and not on "science" or "technology".

We looked at these patterns in the context of a hypothesis that the greater the consistency across institutions, the less susceptible disciplines were to institutional factors and the greater the need for any proposed action to take place at systemic discipline level. Conversely, the greater the degree of variability across institutions, the more susceptible the discipline is likely to be to institutional factors, and therefore to institutionally-based policy approaches.

We can illustrate this diagrammatically by contrasting the particular patterns of enrolments for Physics, Chemistry and Geology respectively. Again, the **mean percentage** is used as the baseline for comparisons between disciplines here. This baseline is used because it allows comparison of enrolment percentages independent of actual enrolment numbers.

Diagram IV(3)

Physics Undergraduate Enrolments in 1985

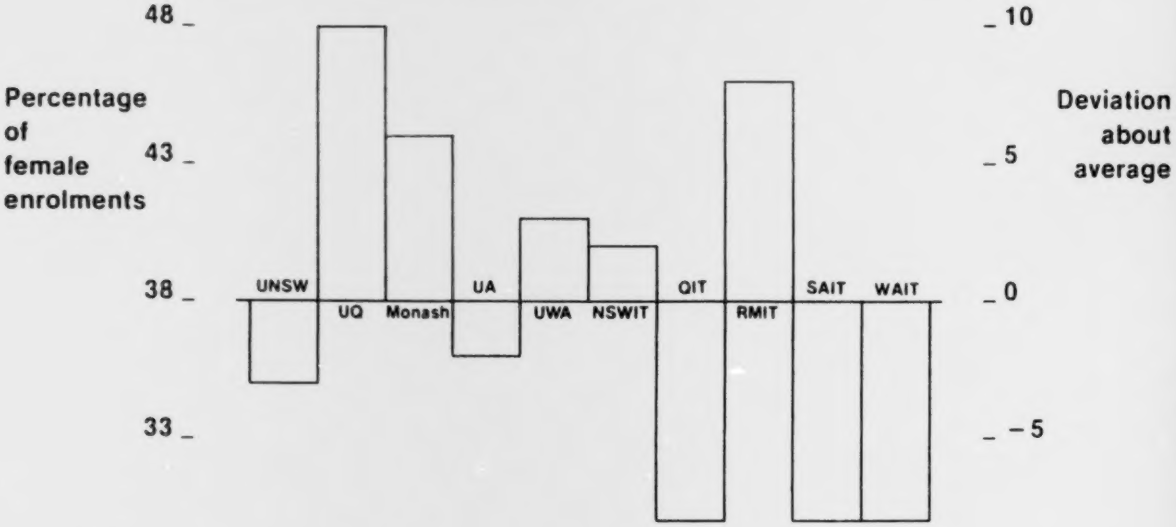


It will be seen that the University female enrolments for Physics are consistently higher than those in Institutes. There is only a small deviation overall from the ten-institutional average, however, and women were fewer than one-fifth of the Physics enrolments for the ten institutions as a whole.

By contrast, Chemistry shows a highly variable inter-institutional variation. There is a much wider deviation from the average; and the mean itself is twice that for Physics, and is well above the sex-normal (for females) threshold for critical mass.

Diagram IV(4)

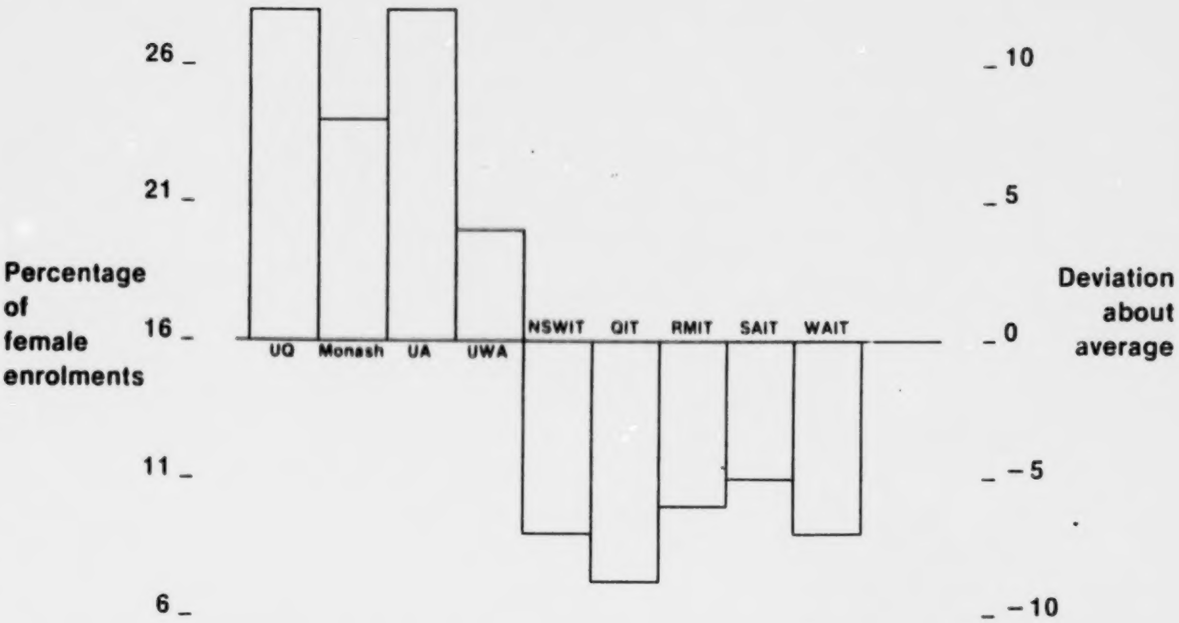
Chemistry Undergraduate Enrolments in 1985



Geology shows a different pattern again. With a mean percentage of 16 per cent across the ten institutions, the deviation from the average is more than 10 points above and 8 points below the average. But the University female Geology enrolments are consistently higher, and the Institute enrolments lower, hypothetically partly because the University Geology courses are more free-floating and science-based than the applied and tightly structured Institute courses.

Diagram IV(5)

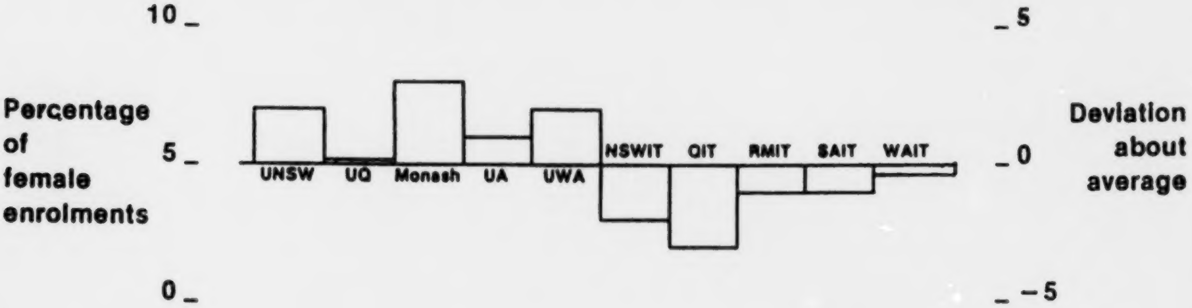
Geology Undergraduate Enrolments in 1985



Although Engineering as a whole still recruits poorly from women in Australia, there are inter-institutional differences in pattern even between the subdisciplines. Electrical Engineering recruited uniformly at the lowest of all disciplines with minimal interinstitutional variation:

Diagram IV(6)

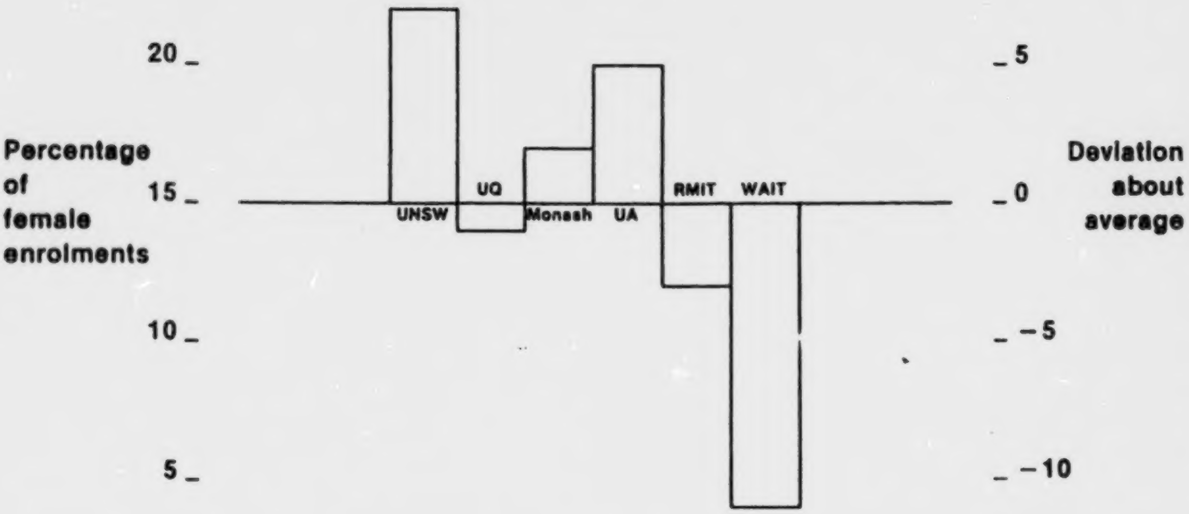
Electrical Engineering Undergraduate Enrolments in 1985



Chemical Engineering by contrast shows marked variations showing stronger institutional influences:

Diagram IV(7)

Chemical Engineering Undergraduate Enrolments In 1985



We now look in more detail at the numbers in each discipline and level.

PHYSICS

In 1985, across Australia as a whole, girls represented only 27 per cent of all candidates at Grade 12, ranging from 25 per cent in Victoria to 32 per cent in Western Australia. Numerically, this needs to be seen against an overall decline in science enrolments in the 1980s at school level. Women were, predictably therefore, only 19.4 per cent of all Physics undergraduates in the survey institutions, ranging from the Institute low of 9 per cent at SAIT and 10 per cent at RMIT, to 23 per cent at the University of Western Australia.

In terms of *access* to Physics at undergraduate degree level, it is interesting that Western Australia had both the highest Grade 12 and the highest University enrolments. The "ceiling" of female enrolments at about a quarter at Grade 12, clearly puts a ceiling on tertiary recruitment. In terms of the Byrne scale of nontraditionality, they are below the threshold of critical mass at the "sexnormal for women" level; that is, at the "untypical" level in the Universities, and at the "abnormal" level in the Institutes.

It was considered possible that the difference in the proportion which Physics students as such (as distinct from those taking Physics as a service subject for, say, engineering) were in the institution as a whole, might be a factor of influence. We therefore checked this out also. In the Universities, the total number of Physics undergraduate students as defined for the survey ranged from 104 to 803. A check on all Physics undergraduates, on women as a percentage of these, and on all Physics undergraduates as a percentage of all undergraduates across the ten institutions, reveals no traceable consistent pattern. Table IV(8) illustrates selected examples to show the range:

Table IV(8)

Institution	All Physics Undergrads	Women as % of all Physics Undergrads	Physics Undergrads as % of all Undergrads
UWA	803	23.3	10.9
Monash	396	20.5	5.8
UNSW	104	20.2	0.8
UQ	406	19.0	2.9

These institutions, which had the four highest female enrolments, show diversity in both the size of the total cohort and the proportion of that cohort to the overall body of undergraduates.

In terms of ***progression*** within the discipline, the female *proportion* (as distinct from number) is not, however, carried through to postgraduate level in appropriate relativity. The phenomenon of cascading losses is particularly acute in Physics. That is, Physics loses more of its women students along the way than most other sciences in our sample. Across our ten institutions, women were 7.7 per cent in 1985 and 7.9 per cent in 1986, of all postgraduate Physics students. But the actual figures are minimal - only one female student at UQ, QIT, Monash and RMIT, for example. The University of New South Wales (UNSW) was the only institution where women Physics postgraduates reached even double figures (ten students = 14.8 per cent). In overall numbers, women were only 20 out of 237 postgraduates in 1985, and 22 out of 250 in 1986. But of these, only seven (six at UNSW) and one at Monash) were PhD students.

Only five institutions had any women Physics staff at all. UNSW had five women staff (8 per cent), QIT one (4 per cent), Monash one (5 per cent), UWA 2.5 (13 per cent) and RMIT seven (20 per cent). It will be evident that traditional role model theory is not supported by the Physics data: the institutions with higher female enrolments do not consistently have more women staff; and vice versa. While UNSW does have one of the highest proportions of women undergraduates, a higher postgraduate female enrolment and more women staff, this correlation (or its inverse) does not appear in any of the other nine institutions. The University of Adelaide, for example, has a higher female student enrolment at both levels than the ten-institutional average, but no women Physics staff.

As part of the profiles, we have looked at the descriptions of Physics in the institutions' handbooks from which potential entrants select courses. Here, we did, by contrast, find a more consistent (but still not universal) pattern. Female enrolments are consistently lower where the discipline is marketed and structured as an applied science; and generally higher where the discipline is described as more free-floating and widely relevant. Female enrolments are also higher where the discipline is located in a Faculty of Science, and lower where in a Faculty of Applied Science.

For example, at the University of Queensland, Physics is located in the Faculty of Science. Physics is described in terms of its fundamental role in science, with reference being made to studying the subject *"in its own right"* or *"because it is relevant to the understanding of other natural sciences such as chemistry, geology and biology"*. Physics at Monash University is located in the Faculty of Science. Physics is similarly described in terms of its pivotal role in science - a discipline which ranges from *"the very practical ... to fundamental philosophical questions about reality"*. There is no reference to specific industrial or other technical applications in the general introduction. The course *"provides a sound scientific background for today's complex and technologically oriented world"*.

By contrast, the Institutes stress the applied nature of the discipline. QIT, RMIT and WAIT had below average female enrolments for Physics. At Queensland Institute of Technology, Physics is located in the Faculty of Applied Science. The general introduction in the handbook says *"the course emphasis is on applied and experimental Physics"*, adding that the course has been structured to satisfy the requirements of future secondary school science teachers, as well as for those undertaking scientific careers in industry or government.

At Royal Melbourne Institute of Technology, the Department of Applied Physics is located in the Faculty of Applied Science. Both aspects of the discipline are mentioned in the opening sentence: the programme giving *"thorough training in both the fundamentals and applications of Physics"*. It then lists a number of major technical areas in which the discipline's developments have taken place, indicating the applied emphasis of the discipline at RMIT.

At Western Australian Institute of Technology, the Department of Physics is in the School of Physics and Geosciences in the Division of Engineering and Science. The course *"will meet the needs of physicists who intend to work in industrial and government laboratories, in atmospheric and marine sciences as research assistants, environmental officers and meteorologists, and in hospitals as medical physicists"*. It mentions a broad range of careers in which a background in Physics should be particularly useful - business, scientific, civil service, data processing, and teaching. There is no discipline description as such.

CHEMISTRY

Chemistry is both a **foundation** science and a service subject to other disciplines; and a specialism in its own right. As such, the subject is doubly important in the context of UQ WISTA analyses, for it carries the potential role of a critical filter, and the status of a discipline leading to career advancement as such. Its intrinsic interest is enhanced by the possible role it plays in the higher-than-average recruitment of women to Chemical Engineering, as distinct from other branches of Engineering. Furthermore, questions arise as to the role that the method, content and ethos of first year Chemistry in higher education plays in relation to the higher recruitment of females to males to Biochemistry, and the higher recruitment of males to females to II-IV year undergraduate Chemistry as such.

If we measure secondary school Chemistry by the Byrne scale of nontraditionality, Chemistry at Grade 12 in Australia would be ranked as theoretically sex-neutral. That is, it is not excessively male-dominated, girls being an average of 39.4 per cent of Grade 12 enrolments across the five largest Australian States in 1985. The interstate differences are not, however, insignificant. South Australia's female enrolment for Grade 12 Chemistry was 35.5 per cent, or just at the borderline of sex-neutrality; Queensland's female proportion was 37.6 per cent; Western Australia's female enrolments were 39.2 per cent; while in Victoria girls were 41.9 per cent of all Chemistry Grade 12 enrolments in 1985.

But there is a critical filter effect within Chemistry (as with Mathematics and Geology), which is partly a reflection of the Maths critical filter and partly the pure/applied science filter. We cite here the example of Tasmania but the filter effect is evident in some other States.

In Tasmania, the Higher School Certificate subjects are offered at Level II and Level III, the latter being of a higher standard than Level II. Level III subjects are the main group which are used by the University in determining the matriculation status of students. Of the required six subjects for matriculation, only two can be Level II subjects. In Tasmania, girls were 36.1 per cent of Grade 12 Chemistry enrolments in all. When we divide these by level and content, however, girls were 40.5 per cent of Level II Chemistry and 37.8 per cent of Level IIIA Chemistry, **but only 29.8 per cent of Level IIIB Chemistry**. The Tasmanian figures confirm the general trend for female enrolments to fall when either:

(a) a subject is described and designed as applied,

(b) a subject is more advanced, or

(c) a subject contains more applied (as distinct from pure) Maths.

The Tasmanian sex-differential between Chemistry IIIA and Chemistry Level IIIB, is revealing. Chemistry IIIA is the main subject covering physical, inorganic and organic Chemistry and is described as aiming *"to give students a firm foundation for further study in Chemistry"* as well as for study in its own right. But Chemistry Level IIIB is described as a *"one-year syllabus* ***containing more mathematical treatment*** *than Chemistry IIIA"*, and it is recommended that Chemistry Level IIIA be also studied previously or concurrently. Thus, it appears that **even in Grade 12 Chemistry enrolments, Mathematics (or the lack or inadequacy of it) acts as a critical filter**. Level IIIB is described as aiming more to develop scientific method, to develop hypotheses, and to apply concepts and principles to the solution of problems.

So far, we note that girls choose Chemistry generally at Grade 12 at a rate well above the critical mass level, and at a level for the subject to be seen as reasonably sex-neutral. But we also note that the sex-differential widens when the subject is subdivided, in direct relation to the introduction of more mathematical and more applied content.

We have compared the State percentages of Grade 12 Chemistry students who are female, with the percentage of undergraduate students who are female in each of the two survey institutions in the relevant same State. These are set out in Table IV(9) on the next page.

It must be noted that the undergraduate figures are not cohort figures directly arising from the previous year's Grade 12 cohort. They include undergraduate students of all ages. As with the diagram above, the figures show a highly variable inter-institutional pattern of female enrolments very different from that for Physics. Although the Monash figures are inflated by inclusion of students studying Chemistry from other Faculties, the omission of these is unlikely to pull Monash below the ten institutional average. As we have seen in Diagram IV(4), unlike the Physics figures, the Chemistry enrolments in the Institutes are highly variable - 30 per cent in SAIT and WAIT but above the institutional mean of 38 per cent at NSWIT and RMIT.

TABLE IV(9)

FEMALES AS A PERCENTAGE OF CHEMISTRY ENROLMENTS

State	Grade 12 Enrolments		Undergraduate Enrolments	
	1985		1985	1986
	F%		F%	F%
New South Wales	39.9	UNSW	34.9	34.6
		NSWIT	40.1	42.1
Queensland	37.6	UQ	47.7	46.2
		QIT	29.9	29.6
Victoria	41.9	Monash	44.1	43.5
		RMIT	46.3	49.4
South Australia	35.5	U. Adel.	35.9	33.4
		SAIT	30.1	28.6
Western Australia	39.2	UWA	40.7	42.7
		WAIT	30.2	30.1

Notes: UNSW excludes Engineering.
Monash includes all Chemistry students regardless of Faculty of enrolment.
University of Adelaide includes Electrical and Chemical Engineering and excludes all other Engineering.
SAIT includes Chemical Technology.
Undergraduate figures include mature age and overseas students.

Despite the relatively high female enrolment to first year Chemistry in the higher education institutions, the subject, nevertheless, suffers from the same "cascading losses" as other more overtly nontraditional subjects. Over the ten survey institutions as a whole, the female proportion of postgraduate Chemistry enrolments drops to 19.2 per cent overall. But at Doctoral level, only 17.3 per cent of Chemistry PhD students were females in 1985. Within the Universities, the overall postgraduate Chemistry female percentage ranges from 9 per cent (Adelaide) to 29 per cent (Monash); and in the Institutes, from 12 per cent (RMIT and QIT) to 16 per cent (NSWIT) in 1985. The variations are greater in 1986 - from 10 per cent (SAIT) to 21 per cent (WAIT) and 22 per cent (NSWIT).

The only reasonable explanation for these sharp and wide variations, can lie with *institutional* factors: the marketing of the discipline, its structure and content, and mentorship (or the lack of it) by staff. Reasons for high consistency at Grade 12 and undergraduate level followed by high variability at postgraduate level, can most likely be accounted for by **variations in undergraduate experience.**

Nor can the proportion of women staff be used as an explanation. Two Universities had no women chemists on staff but had one-fifth female postgraduates. RMIT (three women staff, 9 per cent) and SAIT (two women staff, 10 per cent) had lower female postgraduate Chemistry enrolments of below one-eighth.

In looking at the possible influence of the discipline's description, structure and approach, a possible relationship between higher female access or progression and the extent to which disciplines are marketed as free-floating or applied, is less clear at undergraduate level than for Physics. Certainly the University of Queensland's high female recruitment of 48 per cent correlates well with its description of Chemistry as, inter alia, in a *"pivotal situation in relation to many other physical, biological, physiological and technological disciplines. The subject can be studied in its own right or in conjunction with other subject areas"*. Similarly, Monash (44 per cent) stresses *"the unity of the subject avoid(ing) sharp divisions on merely traditional lines"*, but UWA (41 per cent) has no general description, and NSWIT's description *"emphasising its industrial application, ... preparing a student for entry to professional work in the field of applied chemistry"* resulted in a female undergraduate recruitment of 40 per cent, markedly lower than the University of Queensland, but still gender-neutral.

BIOCHEMISTRY

Biochemistry recruits at second year level, and the factors which influence recruitment are more likely to lie in students' experiences of teaching, mentorship (or lack of it) and peer pressures or attitudes in first year Chemistry and other sciences, than in the marketing of the subject in the handbooks. That is, influences lie primarily in the "ecological niche". Unlike Chemistry, Biochemistry is marketed as related to *"living organisms ... biochemistry may be described as the language in which many biological questions are formulated and ultimately answered"* (UQ) and (in relation to the Grade 12 patterns discussed, *"a study of chemical processes of living organisms, and requires a background of biology and chemistry and, to a lesser extent, of mathematics and physics"* (UNSW).

Biochemistry needs to be seen in relation to the Chemistry profile. For one reason why women are less well represented at higher levels of Chemistry as such, may well be because they represent a majority of the students who go on to Biochemistry.

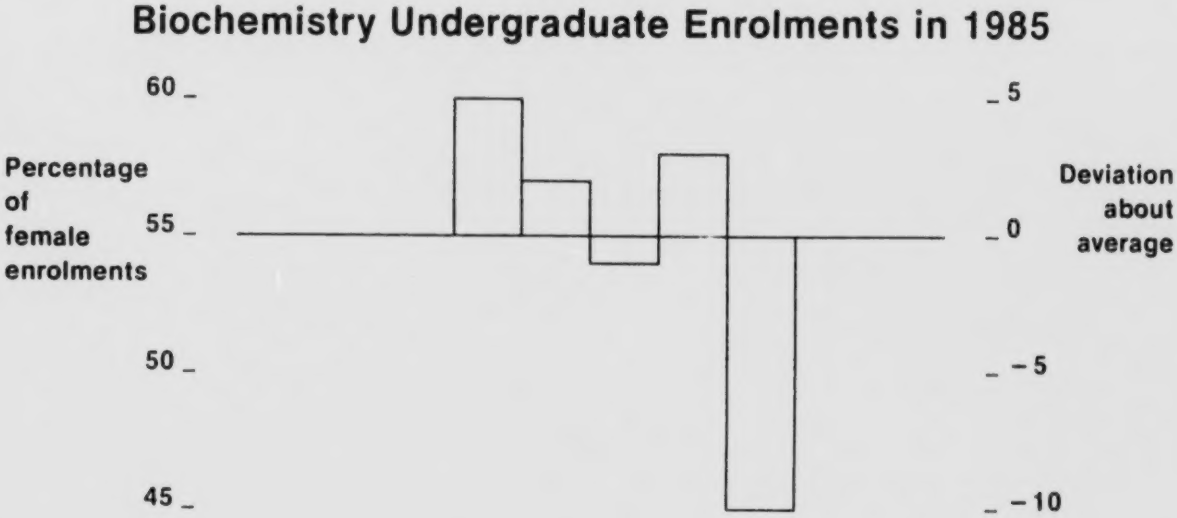
TABLE IV(10)

BIOCHEMISTRY

University	Undergraduate		Masters Research		PhD	
	F	F%T	F	F%T	F	F%T
UNSW	74	60%	11	100%	1	9%
UQ	184	57%	6	32%	11	33%
Monash	139	54%	4	40%	37	71%
Adelaide	100	58%	-	-	15	44%
UWA	264	45%	2	100%	4	24%

It will be seen that the inter-institutional variations are particularly marked in Biochemistry. The undergraduate pattern is illustrated in Diagram IV(8) below.

Diagram IV(8)



The discipline shows a high degree of variability at *postgraduate* level as between Universities. At UNSW, eleven out of twelve female postgraduates were studying at Master's and not PhD level; at Monash, 37 out of 41 female postgraduates, conversely, were studying at PhD level. At UQ, the female percentage was relatively constant at 32 per cent (6 Masters students) and 33 per cent (11 PhD students). The postgraduate female figures were consistently higher than the science or technology overall averages, but with major inter-institutional variations.

COMPUTER SCIENCE

This discipline is of particular significance, not only because of its high relevance to technological development and change, but because it is a new discipline without a long history of male domination like mining or engineering and ought therefore theoretically to be sexneutral.

Figures for Computer Science as a separate subject at Grade 12 level are available for only two of the survey States plus Tasmania. The female percentage of Grade 12 Computer Science students for these three States ranges from 28.3 per cent to 36 per cent. Females were 29.9 per cent as a percentage of the total Grade 12 Computer Science students across the three States.

The female percentage of Computer Science undergraduate enrolments across the ten institutions in five States was 24.9 per cent. However, the female proportion of undergraduate Computer Science students in each of the ten institutions ranges widely from 9.4 per cent at QIT to 37.6 per cent at the University of New South Wales. A more consistent pattern emerges when the institutions are considered as State pairs. The percentage of female undergraduate enrolments is significantly higher at the University than at the Institute in all of the four States for which we have complete pairs of figures to compare (WAIT has no separate figures for Computer Science at undergraduate level).

Table IV(11)

Undergraduate Female Enrolments, 1985

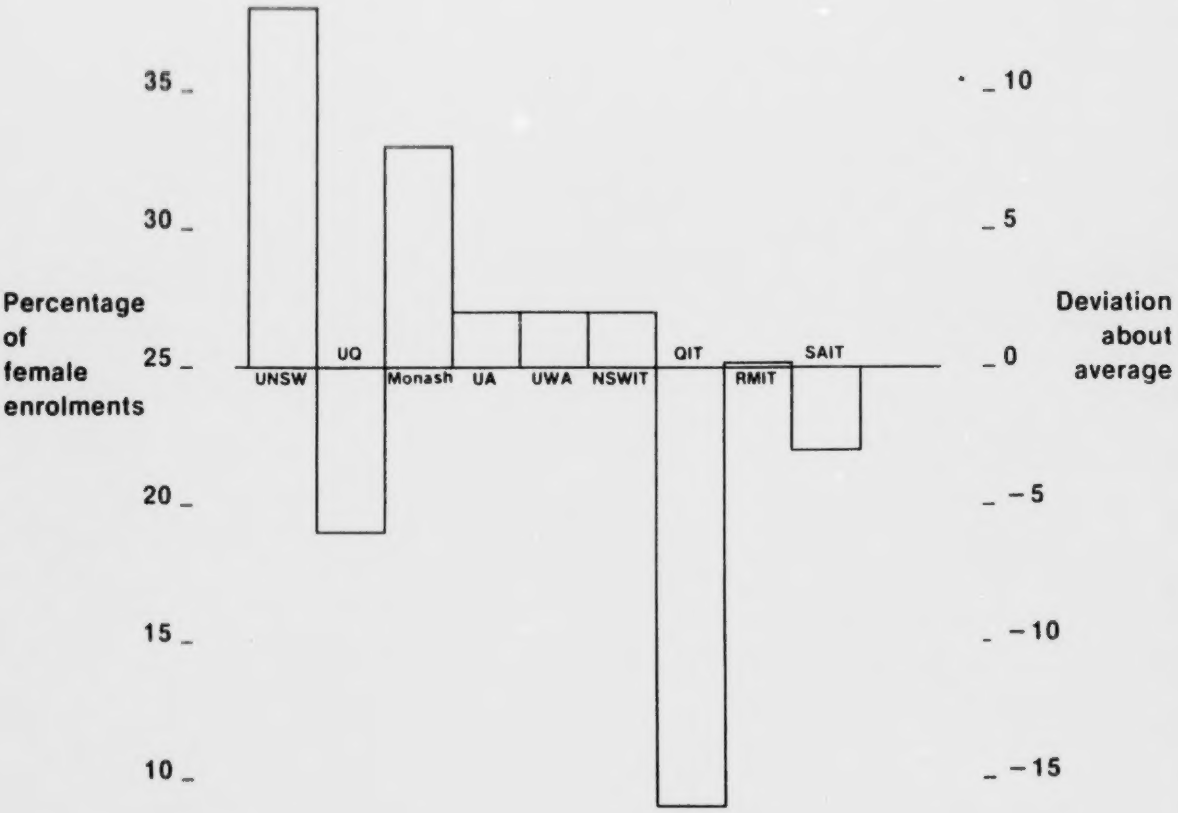
NSW		QLD		VIC		SA	
UNSW	37.6%	UQ	19.2%	Monash	32.8%	U of A	26.8%
NSWIT	26.5%	QIT	9.4%	RMIT	24.9%	SAIT	22.0%
[1.4:1]		[2.0:1]		[1.3:1]		[1.2:1]	

Unlike the statistics for Physics, the actual numbers of female undergraduate students are significant, ranging in the Universities from 91 (UNSW) to 174 (Monash).

The pattern is illustrated in Diagram IV(9) below: most of the Universities recruited above the interinstitutional average - but so also did NSWIT from the Institutes. The sharp University/Institute split seen for Geology (Diagram IV(5) above), does not apply to Computer Science.

Diagram IV(9)

Computer Science
Undergraduate Enrolments in 1985



The proportion of females at undergraduate level did not carry through to the postgraduate level, although the drop is not uniform across different postgraduate levels. Across the institutions in this study, the figure dropped to approximately two-thirds of the undergraduate percentage - ie 17.4 per cent of the total postgraduate Computer Science students are female. This postgraduate percentage was calculated on all Computer Science students undertaking postgraduate study of any kind including Graduate Diplomas.

The female percentage of postgraduate Computer Science students at Masters and PhD level only, however, was 8.2 per cent, and at the PhD level, the female percentage dropped further to 5.7 per cent, a mere 4 female students out of 70, in 1985.

Thus the pattern of cascading losses still applies in Computer Science despite the newness of the discipline and its description by Deans and Heads of Schools as unbiassed and not perceivedly "masculine". This is strongly influenced by the expanding job market in Computing, offering much higher salaries than academic awards.

Four of the ten institutions had no female Computer Science academic staff. In the remaining six, females were fewer than 10 per cent of staff in the discipline; and only 1 or 2 actual staff members in each case, in no way a perceived critical mass. In this discipline also, the role model factor proves irrelevant. SAIT, WAIT and NSWIT which had the highest proportion of female postgraduate students (21.6 per cent, 20.5 per cent and 18.8 per cent respectively) all had no female staff. The University of Queensland with the lowest female postgraduate student proportion, also had no female staff. QIT had the highest proportion of female staff (10 per cent) and a female postgraduate percentage of 12.5 per cent. However, this 10 per cent was only one female staff member.

GEOLOGY

Geology is of interest for a number of reasons. It is a more variable subject in its capacity to attract female students than its apparently cognate disciplines of Mining, Surveying and Mineralogy.

In 1985, the percentage of Grade 12 Geology students who were female varied markedly across the five States being surveyed ranging from 10.5 per cent in Western Australia to 61.4 per cent in Victoria. However, the high Victorian percentage accounted for only 102 female students, whereas in New South Wales 258 female students comprised only 28.2 per cent of the total.

Females as a percentage of the total Grade 12 Geology students across the five States represent 32 per cent of total enrolments.

Table IV(12)
Grade 12 Geology 1985

State	Male	Female	Total	F as %T
NSW	656	258	914	28.2%
QLD (Earth Science)	536	186	722	25.7%
VIC	64	102	166	61.4%
SA	441	305	746	40.9%
WA	145	17	162	10.5%
Totals	1,842	868	2,710	32.0%

The female percentage of undergraduate Geology students across the ten institutions was 18.7 per cent in 1985 and 19.2 per cent in 1986, but the actual total number of female undergraduate students is relatively small. Geology undergraduates as a percentage of the total undergraduate population across the ten survey institutions were 1.3 per cent.

Diagram IV(5) on page 90 illustrated the clear University:Institute differential in female recruitment for Geology quite sharply as a pattern. The female percentage of the total Geology enrolment at undergraduate level at each survey University is 2 or 3 or 4 times more than that at the survey Institute in the same State.

Table IV(13)

Undergraduate Female Enrolments, 1985

QLD		VIC		SA		WA	
UQ	28.0%	Monash	23.8%	U of A	28.0%	UWA	19.9%
QIT	6.8%	RMIT	9.9%	SAIT	11.4%	WAIT	8.1%

Expressed as numbers, the proportional differences are even more significant.

Table IV(14)

Geology Undergraduates 1985

	M	F	T	F%T
UQ	116	45	161	28.0%
Monash	93	29	122	23.8%
Adelaide	154	60	214	28.0%
UWA	233	58	291	19.9%
NSWIT	97	10	107	9.3%
QIT	68	5	73	6.8%
RMIT	118	13	131	9.9%
SAIT	31	4	35	11.4%
WAIT	102	9	111	8.1%

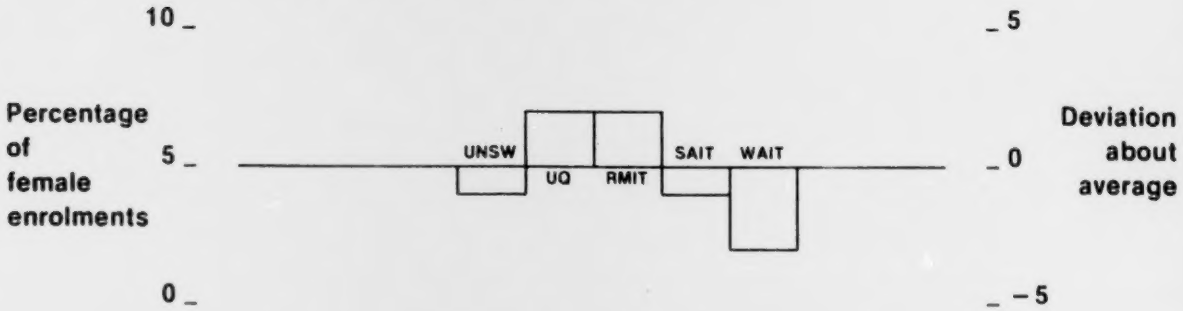
The same number of female students at Adelaide represent a much higher proportion than at UWA. In terms of critical mass, however, Geology female undergraduates overall (and even less by year group) do not reach the threshold of sexnormality or sexneutrality in any institution.

The proportion of females at undergraduate level in Geology is not carried through to the postgraduate level. Over the institutions in this study, the figure drops by close to half, with only 9.9 per cent of the total postgraduate Geology students being female in 1985, and 11.6 per cent in 1986. At the PhD level the female percentage rises to 12.5 per cent, although these proportions are still only half the average female percentage for PhD enrolments as a whole.

It is interesting to contrast the Geology pattern with that of Minerals, which had almost no female recruitment.

Diagram IV(10)

Minerals Undergraduate Enrolments in 1985



Geology merits further study. UWA has the lowest University female undergraduate enrolment in the subject in our survey (19.9 per cent in 1985; 19.7 per cent in 1986) but a total postgraduate female enrolment in Geology of 20.3 per cent in 1985 and 21.2 per cent in 1986. Given the female postgraduate figures in the other Universities of less than 12 per cent in Geology or under half the national average for female PhD students, this appears to be further supportive evidence of the influence of institutional ecology or at the level of the ecological niche (the discipline); or of specific mentorship.

Geology is also one of the disciplines which does provide strong supporting data for the ***grounded hypothesis*** that the more a subject is taught as a free-floating science, the higher the female enrolment, and the more the same subject is taught as an applied, structured, less flexible subject, the lower the female enrolment, both at undergraduate and postgraduate levels.

ENGINEERING

Engineering as a discipline has been more widely surveyed in many countries than any other in relation to women's recruitment, and yet it has proved more resistant than most to change.

Diagrams IV(6) on page 90 and IV(7) on page 91 above illustrated female enrolment patterns for Electrical and Chemical Engineering, with minimal female enrolment across all ten institutions and *minimal interinstitutional* variation in Electrical Engineering, but much wider variations in Chemical Engineering. Table IV(15) below expresses the latter in figures.

Table IV(15)

Chemical Engineering Women Undergraduates 1985

	Females	F % Total
UNSW	101	22.5%
Adelaide	28	19.6%
Monash	21	16.9%
UQ *	15	14.2%
RMIT	20	11.8%
WAIT *	2	4.3%

* excludes common first year.

The numbers and proportion of female enrolments were minimal in Civil and Mechanical Engineering, with very little inter-institutional difference; all below 10 per cent at undergraduate level.

Diagram IV(11)

Civil Engineering Undergraduate Enrolments in 1985

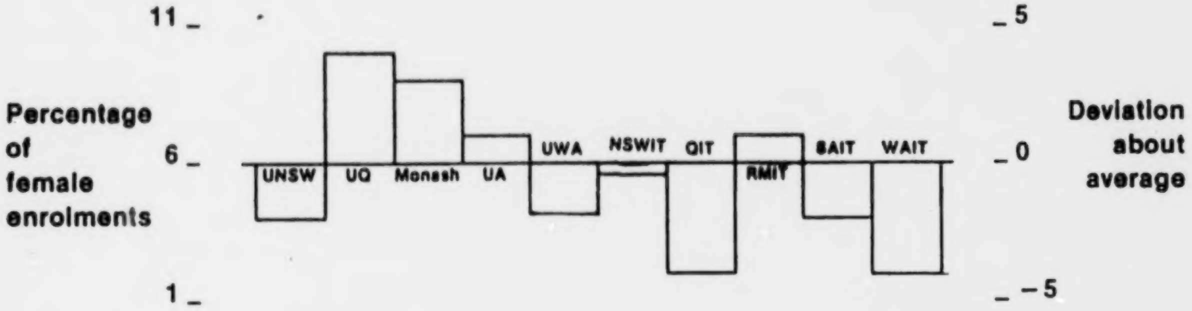
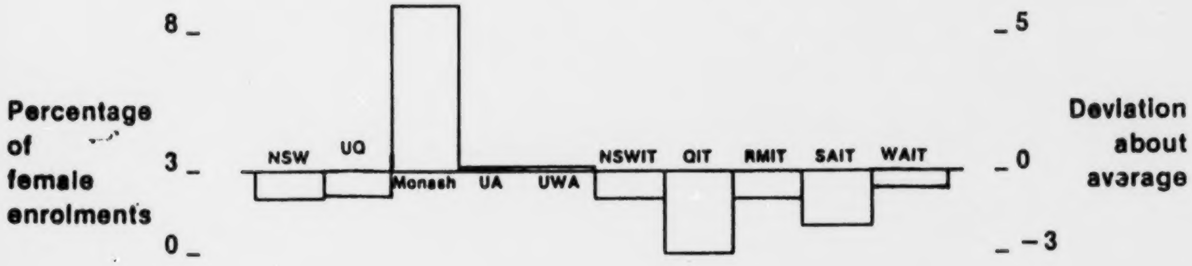


Diagram IV(12)

Mechanical Engineering Undergraduate Enrolments in 1985



There were only 11 women academic staff in engineering across all ten institutions in 1985 and their distribution in no way correlates to female enrolments, because they also are not a critical mass.

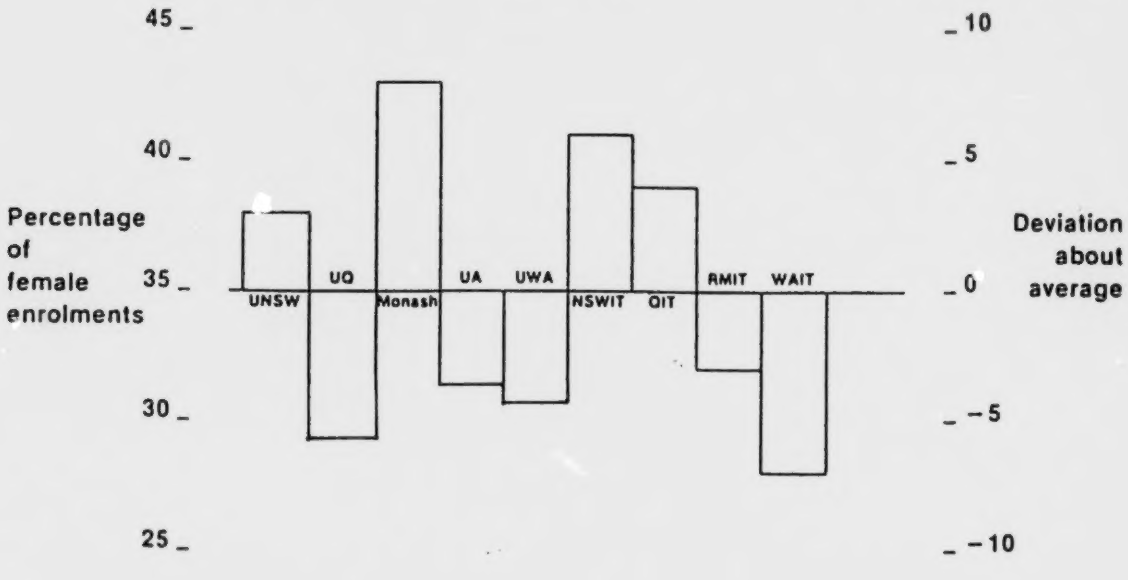
One of the major critical filters to Engineering is in fact, mathematics, on which a separate report is being published because of the complexity of the issues. We merely record here, therefore, the filter effect.

MATHEMATICS

Mathematics as a discipline is complex, and has been the subject of probably more research than any other discipline but engineering. A separate monograph is in preparation on maths as a critical filter, and this report deals only briefly with the issues in the overall context of UQ WISTA theory. Diagram IV(13) illustrates the position of Maths at undergraduate level in our survey institutions - a discipline with high interinstitutional variability.

Diagram IV(13)

Mathematics Undergraduate Enrolments in 1985



The female percentage of Grade 12 Mathematics students as a whole ranged from 40.4 per cent in South Australia to 50.7 per cent in New South Wales in 1985. It must be noted that total numbers of students taking Mathematics at Grade 12 level is an aggregate of all levels of Mathematics and therefore may involve double counting in some instances. Females were 46.5 per cent as a percentage of the total aggregate of all levels of Grade 12 Mathematics students across the five survey States.

Undergraduate Level

The Grade 12 overall female percentage across the five States of 46.5 per cent does not, of course, carry over into the undergraduate figures, where the female percentage of Mathematics enrolments across the ten institutions in the five States was 33.5 per cent in 1985. The female proportion of undergraduate Mathematics students in each of the institutions ranged from 28.5 per cent at WAIT to 43.4 per cent at Monash (SAIT had a zero female enrolment figure because there were no undergraduate students in Mathematics at SAIT other than those studying Mathematics as a service subject). The 1986 ten-institutional average was 33.8 per cent.

No consistent pattern emerges when the institutions are considered as State pairs in relation to percentages of female enrolments. In New South Wales and Queensland, the Institute female percentage is higher than the University one; in the other three States, the University female percentage is the higher one.

Mathematics undergraduates as a whole (both sexes) were 8.2 per cent of the total undergraduate population across the ten survey Institutions in 1985 and 7.7 per cent in 1986. Mathematics is a discipline where the female undergraduate percentage varies very widely - even excluding Monash University's inflated figures, the range varies from as low as 29 per cent (WAIT) and 30 per cent (UWA) to as high as 41 per cent (NSWIT) and 38 per cent (UNSW) in 1985.

As with other disciplines (Chemistry, Geology, Physics and Computer Science) the proportion (as well as the actual number) of female Bachelor and Honours graduates bears no obvious relationship to the female undergraduate enrolment for the institution. The only definite pattern that does emerge at the Bachelor and Honours level is the larger *number* of female graduates at the University in each of the States when considering the institutions as pairs. This was also the pattern with the undergraduate female enrolment figures. The female *percentage* of graduating Bachelor and Honours students (for 1985) is also higher at the University than the Institute in all States except Victoria.

Postgraduate

The overall proportion of females at undergraduate level (33.5 per cent) does not carry through to the postgraduate level, although the drop is not a dramatic one. Across the institutions in this study, the figure drops to approximately two-thirds of the undergraduate percentage - ie, 21.2 per cent of the total postgraduate Mathematics students were female. At the PhD only level, the female percentage drops to 14.1 per cent. At the PhD level, we are also looking at a very small *number* of females - a total of 13 across the ten institutions. At the postgraduate enrolment level, the pattern of female percentage enrolment for the pairs of institutions in each of the States is similar, with the exception of Western Australia. The University percentage is higher at the postgraduate level. (At the PhD level, all enrolments are at the Universities.)

Most remarkable at the postgraduate level is the wide variation of numbers (of both sexes). Thus, at Masters and PhD levels, the 26 per cent of female Mathematics postgraduates at UQ are five out of 14; but the 11 per cent at Adelaide are six out of 54, and the 27 per cent at Monash are 46 out of 123 (1985).

At the postgraduate level, the actual numbers of graduating students in Mathematics are too small for any definite conclusions to be drawn.

Staffing

Across the institutions, there is no apparent clear connection between the percentage of staff who are female and the percentage of postgraduate students who are female. WAIT, which had the highest proportion of female postgraduates in mathematics, had no female staff. The University of Western Australia had the highest proportion of female staff (and also the largest number of female staff) but only the fifth highest percentage of female postgraduates.

At the PhD level there is also no positive connection between female staff percentages and female student percentages. It is interesting to note that all the survey *Universities* had female staff but only two of the survey *Institutes* had any female staff in Mathematics (QIT and RMIT).

COMMENTARY

Before discussing some grounded hypotheses which appear to be supported by our data, one or two *caveats* should be noted.

In some, but not all, disciplines, the figures for one institution are slightly inflated by their apparent inability to have totally separated out Science and Technology students from other Faculty students, or by a small number of Maths or Physics students from one sub-discipline of Engineering. It is important to note, however, that there is no case in which this affects, in fact, the basis of our hypotheses. The reverse is more true; the subtraction of the inflated numbers at the level estimated by the University tends to strengthen our argument.

If we summarise the implications of the data analysed so far against critical mass theory, some interim conclusions emerge which have at least the strength of **grounded theory.**

- **Despite the fact that women are a critical mass at the "sexnormal" level in the undergraduate body at all five Universities, this has _not_, alone, made it possible to ensure a correlational female critical mass pattern at postgraduate level.**

- **Only one institution has some correlation of above average female enrolment at undergraduate _and_ masters research _and_ PhD level. Others show highly variable patterns in the general progression of women.**

- **Moreover, the wide _variations_ between the Universities in female proportionate enrolments at masters research and PhD levels, cannot be accounted for solely by external generic factors. The moderating influence of institutional factors is supported so far by the data patterns.**

- **In none of the survey institutions were the female full-time academic staff a critical mass in the survey disciplines, at the sexnormal/sexneutral level. In most, their proportion of overall staffing was either at the perceivedly untypical or perceivedly abnormal levels. This further places into question, the impact of potential role modelling. The overall female staff critical mass was not yet such as to be likely to be able to challenge the male domination of the cultural ecology of the survey institutions.**

It is recognised that the survey institutions or individual heads of disciplines will wish to show changes or increases in female enrolments for 1987 onwards where these appear to show a more "favourable" profile. This would be to misunderstand the purpose and relevance of our survey. The 1985 and 1986 profiles of disciplines are part of a **diagnostic** exercise. They are _not_ intended to stand as permanent photo-kits of institutions or as predictions of trends. That task is the standing responsibility of institutions themselves.

Critical mass theory, one of our four research dimensions, is relevant to four aspects of the problem: female _access_ at undergraduate level; female _progression_ to postgraduate work; female _role modelling_; and the _image-attribution_ of disciplines as perceivedly "male" or "female", or masculine or feminine. The data analysis across ten institutions and a variety of disciplines **does not alone support** a hypothesis that the higher the critical mass of women in the institution as a whole, then the higher would be the proportion of women undergraduates in the scientific and technological disciplines. Some of our survey institutions have, for example, a lower than average overall female enrolment and a higher than average female undergraduate science and technology enrolment; and vice versa.

We conclude that

- **critical mass of a group in overall enrolments may still contribute to the overall institutional ecology - we believe that it does - but it will not alone achieve improved female participation.**

In terms of progression to postgraduate study, the position is, however, more complex. It would be tempting to argue, for example, that because Biochemistry and Microbiology have a consistently higher than average female enrolment at both undergraduate and postgraduate levels, critical mass is influential; but this is still tenuous. The position is modified also by the fact that some disciplines have a female enrolment lower than average in undergraduate study, but higher than average in postgraduate study (UWA Geology); but that others show consistent cascading losses regardless of the *variable* levels of their undergraduate female enrolments (Computer Science; Physics; Chemistry). We retain critical mass as a *potential* influence in the cluster of factors related to progression, but with an open mind. Further study of this is needed.

Its relevance to role modelling and to the attribution of disciplines as masculine and feminine, is interdependent. In addition to the clarification of role modelling in Chapter V (following) we believe that our data analysis showing where women are (and aren't) in undergraduate and postgraduate study and as academic staff in each discipline,

- **supports a grounded hypothesis that the mere presence of women academic staff is not influential as a role-modelling process to encourage postgraduate progression, unless women are sufficiently above the critical mass threshold of sexnormality or sexneutrality (probably over 33 per cent) to represent their discipline as normal for females.**

- **suggests that women staff in the survey disciplines will not, however, reach that critical mass threshold in the next decade by the normal progression from postgraduate study to higher education teaching, because the female critical mass threshold has not been breached at postgraduate level, except in Biochemistry and Microbiology.**

It may also be noted here that the Deans, Professors and Heads of Schools in the group interviews agreed widely that those women who did achieve distinction in the survey disciplines, were more unlikely to enter Academe in areas like Computer Science or Engineering, because of the higher immediate financial and professional rewards in the mainstream of the disciplines in industry and commerce. They saw their women postgraduates as making "realistic labour market choices" as a highly marketable commodity.

In terms of the gender-attribution of disciplines, the data analysis does, we believe,

* **support a hypothesis that the proportion of women in a discipline in which they are a minority, is directly related to and influential in the attribution of that discipline as untypical for women; abnormal for women (ie actually "unfeminine" and acting out of the sex norm); or the rubric of exceptions to the level of not being seen as transferable to other women. (*"But she is different." "But you can't use her as an example."*)**

When we relate the actual proportion of women staff and students in the survey disciplines to the descriptions of those disciplines by staff from each discipline either attending the group interviews or responding to the Image Discussion Paper, there is support at the *grounded theory* level for a hypothesis that

* **the thresholds between these proportions of female enrolment are of the order of**

33 per cent or more	**:**	**sexneutral**
16-29 per cent	**:**	**sexnormal for males but untypical for females**
9-15 per cent	**:**	**abnormal for women**
8 per cent and below	**:**	**abnormal and so exceptional as to be not seen as a transferable example.**

The relevance of this is that the strategies for reviewing disciplines would vary according to the different critical mass thresholds and the image-perception of the disciplines.

In terms of **institutional ecology theory**, the data analysis establishes both significant inter-institutional differences and significant interdisciplinary differences. The data analysis and discussion in this Chapter have established some recurrent profiles which apply to some disciplines but not to others; and to some patterns which apply differentially at postgraduate levels only. The very range of levels and types of differentiation discussed supports, in our view, hypotheses that:

* **future research should move from the paradigm of examining women and girls to the paradigms of examining (a) the institutional ecology of their learning environment and (b) the ecological niche of the Department and of the individual discipline, and not "science" or "technology" as allegedly homogenous areas of study. This is likely to produce more realistic explanations susceptible to policy change;**

- **some disciplines (Physics, Engineering) appear so little susceptible to institutional influences, or influences at the level of the ecological niche, as to question the wisdom of projects and research money being invested in *institutional* programmes for those disciplines. A more appropriate strategy is an Australia-wide review of the discipline as such, including structure, content and image;**

- **other disciplines show much greater variability and hence susceptibility to institutional and Departmental influences. These will need both review at systemic levels as above, and research review at the level of institutions and the ecological niche of Departments in order to reach credible explanations for variations which still show sufficiently recurrent patterns to be more than idiosyncratic.**

We now turn to the specific factors of role modelling and mentorship in the next two Chapters.

REFERENCE

Australian Bureau of Statistics (1987) Tertiary Education, Australia, Catalogue No.4218.0.

CHAPTER V

ROLE MODELLING AS A POLICY MECHANISM: POOR EVIDENCE FOR THE THEORY

> ***Dux femina facti (a woman the head of the enterprise).***
>
> **Virgil, Aeneid I.**

It is not easy to see why the belief that same-sex role modelling is a useful (let alone effective) ***policy mechanism***, has such widespread currency. We can find no hard, systematic, scholarly evidence to support this. That role modelling is an intrinsic part of the psychological process of growing up, and that *same-sex* role modelling is essential to break stereotypes and to "normalise" an occupation or activity, we do not dispute. But that *"if only we had more women staff, we would have more women students"* is a sensible or rational hypothesis, we do question as a basis for policy making. This Chapter sets out why.

We started the UQ WISTA Policy Review project with a healthy scepticism on same-sex role modelling as a process. We had noted with concern, an extremely loose use of the term not only in lay policy reports, but also in allegedly scholarly research. Much of what has been described as role modelling is no more than the actual, passive presence of a woman. More serious is the constant and widely occurring use of the term role modelling to describe processes which are clearly mentorship. Over half of the written work on role models we have sieved, shows an apparent lack of understanding of the essential characteristics of role modelling, and a concurrent unshakeable conviction that it is present as a policy mechanism and that it works. We question this.

In developing this argument, we should make it clear that we are not necessarily challenging all aspects of role model theory, some of which are still valid and relevant to the understanding of female and male *aspiration and identification* in adolescence. What is in question is the assumption that aspiration alone (even when strengthened by same-sex empathy) will be translated into motivation and then into decision-making, merely by the visible but passive presence of women in nontraditional settings. In this Chapter, we seek to clarify more precisely the various stages of each of the two processes, and the extent to which our data so far support the validity of either in terms of policy mechanisms or outcomes.

WHAT IS ROLE MODELLING? OR SAME-SEX MODELLING?

At the heart of the role modelling process is the question of identity. Only when two things happen, does role modelling take place at all. Firstly, the child, student, trainee *identifies* with an older and very visible person important to them; and secondly, they then *change their behaviour* to imitate that of the adult on whom they feel they should model their actions. Only when both processes are present, does role modelling take place.

The original concept of role modelling derives from educational psychology and is a process by which a child *models* her or his behaviour on that of an adult, receiving praise or negative reactions to different behaviours. It is thus that we acquire, in particular, our sexrole identity in the first place; by praise-reinforced encouragement of same-sex modelling (girls on mother, aunt, grandmother; boys on father, uncle, grandfather), or by very negative and overt disapproval of "cross-sex" behaviour modelled on the opposite sex.

Sexrole Identity

Kagan (1964) identifies a sexrole standard and a sexrole identity. The former is a "learned association between selected attributes, behaviours and attitudes, on the one hand, and the concepts of male and female on the other", and works partly through identification with role models in the adult:child interaction process (parent or teacher). He identifies sexrole identity, however, as rather "the degree to which an individual regards himself or herself as masculine or feminine", and in acquiring this sexrole identity, the role model needs in Kagan's view to be a caring one, to be seen to have the control of goals and skills the child wishes to acquire, and the child needs to be able to see a ***realistic similarity*** between himself or herself and the adult. Kagan is inconclusive on whether the strength of the sextyping of the role model does or does not affect the child's security of sex identity. The role model angle of role identity has been debated further since - Mischel (1966 and 1970) for example argues that more of our identity comes from the social learning of behaviour reinforcement or negative influence, while Gelb (1973) sees sex identity as having been in fact distorted by "coercive institutionalisation of sex roles". Overall there would be agreement with the view that when children move from undifferentiated sex roles (stage I) to polarised sex roles (stage II) in which societal values and pressures produce a perceivedly "normal" set of behaviour patterns for each sex, (Robinson and Green, 1970), the role modelling process as described by Kagan still plays an important part.

This question of *realistic similarity* is central to the same-sex role model debate. Why would adolescent schoolgirls see a "realistic similarity" between themselves and an untypical female physicist or engineer who visits their school once for a careers talk?

Kagan's work, it should be noted, can be criticised for its assumption that anyone who rejects sexrole identity is pathologically abnormal. He acknowledges that "some children either resent or experience anxiety over the behaviours that are assigned to their biological sex" (p.145) but he endorses the assumption that all children "have a need to acquire a self-label that *matches* their biological sex" (my italics). He concedes that some adolescents and adults "strive to avoid adoption of sex-typed responses because of anxiety over the behaviours that are prescribed for their sex role" (p.146), but reasserts the predominance of sexrole ascription over actual individuality. "These individuals are typically in conflict and are likely to manifest a variety of psychopathological symptoms" (p.146). It is true that Kagan concludes by conceding that "unnecessary conflicts are generated because of anxiety over deviation from sexrole standards. Once learned, these standards are not easily altered. But they are modifiable during the early school years ..." (p.163).

We argue in this study that sexrole standards can, in fact, be altered much later and that staff in tertiary institutions have a direct responsibility for creating a different and more sexneutral environment for students who precisely do not wish to be labelled, in Kagan's terms, as showing "psychopathological symptoms" merely because they are choosing to act out of the socially ascribed sexrole standard in the male-dominated higher education milieux! And, indeed, this ascription of psychopathological status to girls who wish to follow a nontraditional curricular or occupational career, is precisely our argument in relation to the minority women in the two more extreme minorities (below 15 per cent and below 8 per cent) in our survey, in the Byrne scale of perceptions of sexneutrality/sexnormality/sexabnormality of minority women in disciplines as set out in our theoretical framework. It will be recalled that we argued that women who are 8 per cent or fewer in a discipline (ie had acted very considerably in contradiction to their normally ascribed traditionality) were perceived as both abnormal and so exceptional as to be unable to be used as a "normal female" model.

The other foundation concept which forms part of role model theory is that of the reference group. We use other people as *reference groups* when we begin actually to use them as a model for our own behaviour. Kemper defined a reference group as "any group, collectivity or person which the actor takes into account in some manner in the course of selecting a behaviour from among a set of alternatives ... A reference group helps to orient the actor in a certain course, whether of action or attitude" (Kemper, 1968). (By actor, of course, Kemper means the person taking active steps to model on another.) Kemper held that reference groups do influence the achievement of those who use them as a guide. Thus groups set the norms and values to be followed, but until individuals test these on an "audience group" which will give feedback (reward:punishment or approval:disapproval feedback), achievement levels and influences on decisions will not, according to Kemper, actually occur.

It is at this stage in Kemper's theory that the individual role model becomes important, in that what was initially a mere desire to adopt a course of action or a set of behaviours, is transformed into a real decision:

> "using an individual rather than a group ... the role model demonstrates for the individual how something is done in the technical sense ... The essential quality of the role model is that he (sic) possesses skills which the actor lacks (or thinks he lacks) and from whom, by observation and comparison with his own performance, the actor can learn". (Ibid, p.33).

Applying this to higher education, Young et al (1980) describe the token woman as using the academic world as her reference group by adopting the prevailing academic ideology which, they allege, includes that the token woman "by virtue of talent and effort in measuring up to the high standards and superior attributes of academic men, (she) is not only exceptional, but an exception to the social category 'women'" (p.509). This is interesting in the light of our UQ WISTA theory about the relationship between critical mass and perceived sexnormality or sexneutrality.

The role modelling concept has now been widely extended to a belief that in the process of shaping "normal" or "deviant" vocational aspirations in adolescence or adult life, or of forming occupational goals, each sex is reinforced more securely in decision making by seeing same-sex role models ahead of them in the power structure (leadership), in the relevant occupational area (science, technical work), or in the sphere of influence they aspire to (politics). In this, relevant theoretical and empirical research tends to support Kagan's perception that the person being influenced by the role model needs to be able to see a "realistic similarity" between herself or himself and the role model; that is, the rubric of exceptions should not operate.

But if role modelling occurs when we use a person or a group as a reference point to imitate them in our behaviour because we feel identified with them (even if it means altering our behaviour patterns in order to be like them), does the model also need to be of the same sex for us to feel that particular identification? Do we only alter our behaviour (choose different career or job?), as a result of the influence of a model of the same sex?

We still do not know what the real messages are which reach adolescents and young adults when they see a same-sex role model ahead of them. Does a Grade 12 girl think only that "women can do that" when she sees a woman engineer or a female University Professor, and not that "I, Jane, can do that"? And what is "that"? Having a career? Combining a career with marriage? Settling happily for a single life with a rewarding career independence? Or handling machines or management ascribed in her circles as "male" and therefore being an untypical woman if she follows her model? And at what point does the adolescent see it as *normal* to follow a role model?

The UQ WISTA research postulates that the adults providing potential same-sex role models (Principals, female Physics teachers, male preschool teachers, etc) are only likely to be seen as "sexnormal" in terms of the particular society's sexrole standards, **if they are a critical mass.** Minorities, and particularly very small minorities, will, by definition, not be seen as typical or "normal", since it is the very characteristics of the majority which are, by definition, the norm.

Moreover, role modelling has been discussed in the research literature predominantly in relation to its effect on the same-sex student rather than opposite-sex student. Its value in the breaking-the-stereotype phase is arguably equally influential where male students see women in nontraditional roles, which can also alter male attitudes and help to liberalise them. That is, until male school students see women in nontraditional roles, presented so far as possible as increasingly normal, they will not alter their repressive, territorial and negative attitudes towards women entering "male" disciplines and occupations. The debate on female role modelling needs to shift from being seen as a process to influence girls' attitudes, ***to a strategy for altering boys' attitudes towards girls.***

An Inappropriate Policy Approach

In the last decade or so, a particular belief has therefore become widespread in most countries and cultures concerned about sexrole stereotyping and about women's underachievement in nontraditional areas. Policy-makers, inservice trainers, field personnel have acquired an entrenched belief that the existence of more women role models would *automatically and by itself*, increase female enrolments in the area represented by the female role models. Thus, it has been argued, the personal visibility of more women School Principals, Vice Chancellors, Technical College Principals and Heads of Departments, Cabinet Ministers, Physics teachers, electrical technicians and plumbers, would result in more girls enrolling in, or seeking leadership in, higher education, technical courses, politics, Physics, electrician training and plumbing respectively.

Because of this belief, projects have been increasingly funded which have had as a central or main policy mechanism, the conscious use of minority or nontraditional women as visible role models to school and college students. This has typically involved women engineers, plumbers, lawyers, accountants, University Science lecturers and other minority women in travelling long distances for time-consuming visits to schools or colleges for careers talks or conventions; or to institutions handling apprenticeship recruitment or trade and technical training. It has also involved nontraditional women extensively in inservice training programmes for staff involved in education, training or management.

In particular, the received wisdom has been based on an assumption that the role modelling process acts in one single, simple step in a direct cause-and-effect relationship between girls seeing or hearing inspiring women and girls, and therefore as a result, altering their curricular choice or vocational aims in one step. **This is wrong, and is founded on a serious misinterpretation of available relevant theory and research.**

We reviewed existing published research in this area as part of the UQ WISTA Policy Review. The UQ WISTA analysis identified a number of weaknesses in the conclusions drawn from much of the evidence cited. For example:

- some widely cited research articles prove to be based on assertion and conviction without a research base;
- some did not follow up their introduction of role models as a conscious policy, to check whether female enrolments actually did increase at all in relevant disciplines or sectors, in subsequent years;
- where some increase was recorded, most projects did not record any research or evaluation methodology which controlled for role modelling to separate it from other coexistent social or educational or psychological factors;
- some research was based on questionnaires so loosely compiled that they either did not distinguish same-sex role modelling from cross-sex role modelling, or they did not define what they meant by role modelling at all;
- no research can be readily traced which follows through over-simplified questionnaire-based student information on female role modelling with interviews to probe the contextual reality of the answers or the relative importance of the process;
- some research with graduate students simply reports that more women than men cite same-sex role models in their Department and assumes a cause-and-effect relationship, but no methodological steps are reported which check

whether the women were already more career-oriented and confident on entering higher education or graduate school;

- some research actually concedes that the research design was so imprecise that "participants" in the study may have had differing views of what constitutes a role model;
- most research describes as role modelling, activities which are active mentorship and have nothing to do with any of the three stages of role modelling described below.

Alternative Role Model Theory

As a result of the research review and subsequent UQ WISTA analyses, we conclude that there are either three or four distinct phases in the role modelling process; not one. Insofar as phases two, three and four occur, they are *sequential*. They each result in order from the previous phase.

(a) In phase one, female role modelling functions as a strategy to **break the stereotype** of the exclusive masculinity of the image of Maths, Science or technology;

(b) In phase two or phase three, a **personal** role modelling process then takes place in which adolescents or young adults use same-sex identification **to strengthen personal decisions to make a vocational or subject choice nontraditional for their sex;**

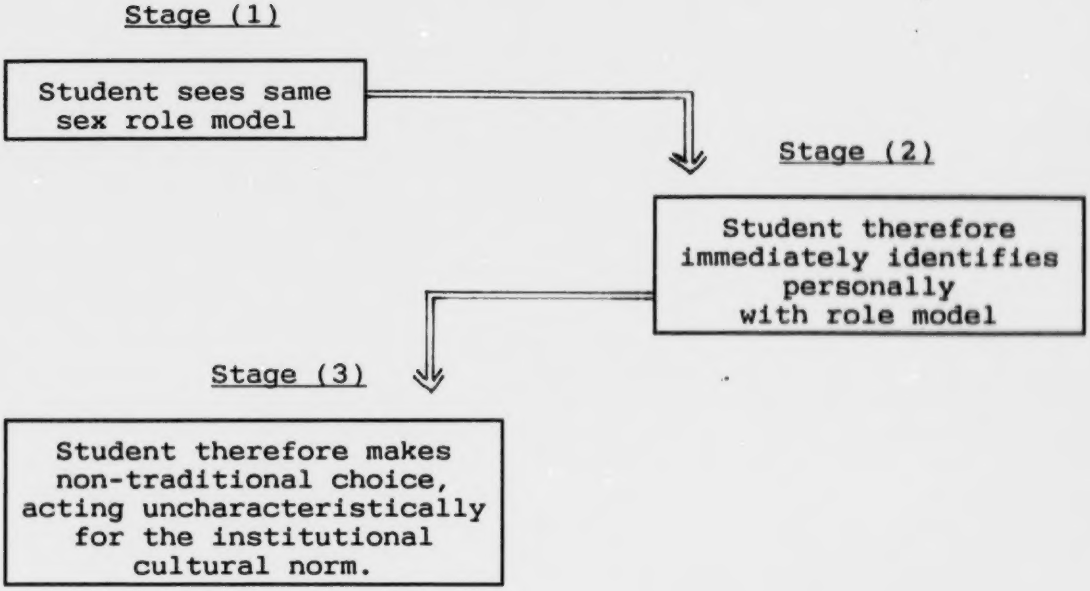
(c) In phase three or phase four, same-sex role modelling acts to **"normalise" an area as either sexneutral, or acceptable or suitable** for either sex in the minority - in this instance generating a feeling of female normality. **This only occurs where the role models are a critical mass.**

These are usually consecutive phases, and most of the effective achievement in female role modelling so far has remained at phase one, the breaking-the-stereotype stage. At this first stage, role modelling can alter or improve female aspiration insofar as it removes the negative barrier of a perception that "women can't do engineering" or that "women can't handle management". The breaking-the-stereotype phase can also be seen to be related to the **image** of scientific disciplines and can remove a negative perceptual access barrier. But unless and until phases two and three and four are also achieved, there is no evidence that the mere removal of the perceptual barrier as such will in turn remove the actual barriers of curricular choice in such a way as directly to increase female enrolments.

Traditional role model theory is illustrated diagrammatically in Figure 5.1. The assumption has been that students move from stage (1) to stage (3) in one simple step, *merely by seeing a passive role model.*

Diagram 5.1

TRADITIONAL ROLE MODEL THEORY



Stage (1)

Student sees same sex role model

Stage (2)

Student therefore immediately identifies personally with role model

Stage (3)

Student therefore makes non-traditional choice, acting uncharacteristically for the institutional cultural norm.

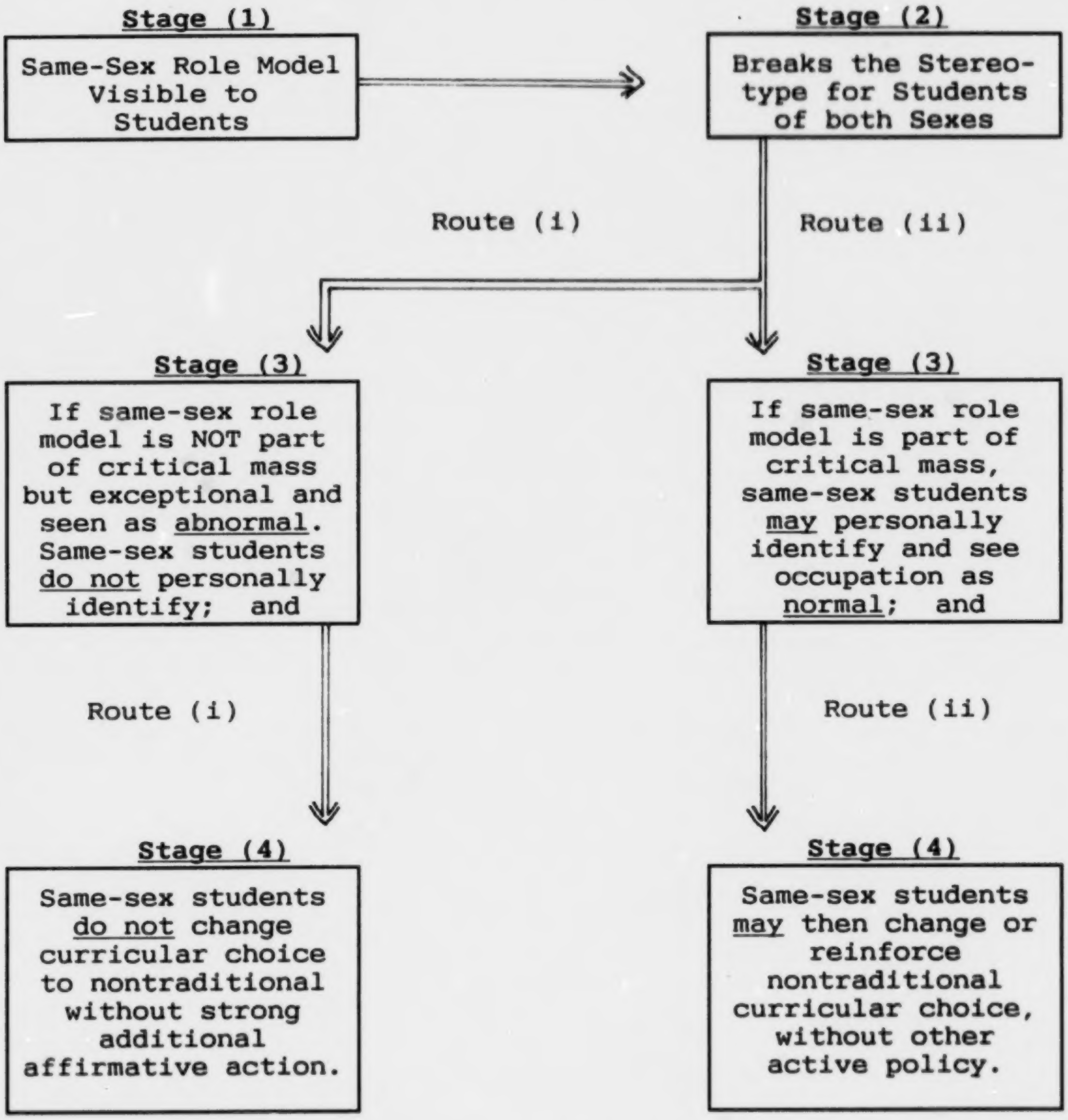
That is, the assumption is that simply because same-sex role modelling breaks the stereotype by mere visibility, the student will immediately identify with the model and therefore alter her or his curricular choice behaviour *and persist in this*. Under no other assumption could the belief that more women role models, as such, would increase female enrolments, have become so widespread. We reject this, and UQ WISTA revised role model theory is set out in Diagram 5.2 on page 120.

There are in fact clearly two routes. Under route 1 to 3, in Diagram 5.1, if the student identifies immediately with the role model, this is either because the student is already as untypical as the model (ie middle class, highly intelligent, independent) or has high self-esteem, or can handle peer pressure, or is quite prepared to become untypical. This almost certainly accounts for the steady small minority (5-10 per cent) of female entrants to engineering and other male-ascribed areas, whom other research overseas and in Australia has already recognised as being a highly untypical group (Byrne, 1985).

But students who continue to conform generally to their sexrole identity, and for whom socially accepted concepts of sexnormality remain important, are less likely so to identify, and less likely to persist in nontraditional choices against negative pressure. These students will follow the second route in Diagram 5.2 of only identifying with role models when these are normalised by being a critical mass of the whole.

Diagram 5.2

REVISED ROLE MODEL THEORY


Stage (1)
Same-Sex Role Model Visible to Students
Stage (2)
Breaks the Stereotype for Students of both Sexes
Route (i)
Route (ii)
Stage (3)
If same-sex role model is NOT part of critical mass but exceptional and seen as abnormal. Same-sex students do not personally identify; and
Stage (3)
If same-sex role model is part of critical mass, same-sex students may personally identify and see occupation as normal; and
Route (i)
Route (ii)
Stage (4)
Same-sex students do not change curricular choice to nontraditional without strong additional affirmative action.
Stage (4)
Same-sex students may then change or reinforce nontraditional curricular choice, without other active policy.

We accordingly started our policy review with several working hypotheses in mind,

- *(a) that same-sex role modelling is an important influence in breaking the stereotypes of masculinity or femininity in the vocational setting;*
- *(b) that the basis for arguing that the mere acquisition of more females in a given discipline or occupation would result in students/trainees using these as role models, is, however, not based on well grounded theory;*
- *(c) that role model theory alone is an inappropriate basis for the construction of policy mechanisms.*

WHAT DOES THE RESEARCH SAY?

Let us now look firstly at what previous research really says, and then at the data and evidence of the UQ WISTA research as a basis for justifying our new grounded theory.

It should be noted that our review has been strictly in the context of the educational process, of the role of education and of the policy-making process. We recognise the importance of parents in the role modelling process and in particular of "working mothers" (or more accurately, mothers in paid employment, since all mothers work). Tangri's doctoral dissertation and (1972) research report on nontraditional occupational choices in American college women has been widely influential in the acceptance of their assertion of the critical influence of maternal role models. Her classification of these into Role Innovators (fewer than 30 per cent women in an occupation), Moderates (30-50 per cent female representation) and Traditionals (occupations with more than 50 per cent women) has also been used for replication studies. While we do not dissent from her findings, we reiterate that this research project has focussed on role modelling and mentorship in the higher education process, on the direct grounds that this can be influenced by the policy process, but that maternal role modelling cannot.

We should first note that role modelling should be distinguished from mentorship, which is an active process of positive sponsorship by older "patrons" (teachers, managers, trainers, counsellors, more senior women staff etc) towards younger or less experienced entrants or trainees, and which we discuss in the next Chapter. The current received wisdom is that hypothetically, a mentor who is also female and a role model will be doubly influential. But sponsorship, grants, the award of jobs, are reflections of the power structure. In science and technology, women are fewer than 2 per cent of the top leadership. Mentors will, therefore, more often still be male.

In summary, we wish to distinguish more clearly, in what has become a considerable conceptual muddle, between same-sex role models who are passive visible "breaking-the-stereotype" agents, and same-sex mentors or sponsors who actively help those following behind. A further distinction needs to be made between *same-sex* and *opposite-sex* modelling or mentorship. Finally, a clearer distinction needs to be made between the identification element in role modelling and the counselling role which more female models/mentors are reported as willing to take on, than male.

In looking at the available research, we now divide the issue further into different but related questions - what evidence is there that same-sex role models do increase enrolments of the (same) minority sex? What evidence is there that same-sex models cause a change of behaviour in younger girls or women sufficient to lead to nontraditional behaviour? Or to nontraditional behaviour which could also be perceived by the student as *normal behaviour?*

Do Female Role Models Increase Female Enrolments?

If we were to look at the assumption that the mere presence of more women role models leads to increased numbers of women students in statistical terms, we should expect to find some degree of correlation between higher than average female numbers at both staff and student levels, and we investigated this in our ten institutions. This should, hypothetically, apply either by sector of education or by institution or by type and discipline. The data presented later in this Chapter shows no correlation whatever. But neither could we trace any previous hard evidence of a correlation in previous research. At the level of sectors of education, for example, a recent international study of the school education of girls did not provide evidence even for a prima facie case. "The most recent UNESCO data on the proportion of women in the teaching profession and the proportion of girls at school show, whatever the level of education, no statistical relation: once again the school system reacts differentially to its environment" (Deblé, 1981, p.104).

Frohreich (1975) in writing of measures to increase female retention rates, simply records as a decisive assertion that "having women on the engineering faculty can be one of the best ways of providing role models" (p.44). Frohreich then jumps straight to the strategy that "women need to be involved in conducting activities to attract more women students to engineering" and argues that because we have few women academics, *women* engineering students or other *female* academics should take this responsibility personally. Sproule and Mathis (1976) provide a useful summary of a survey of twenty-nine American engineering colleges which have been successful in recruiting and keeping women engineering students, analysing and summarising their techniques. More wisely than some, they do not claim to have hard evidence that the factors will work: "Success will be based on a combination of commitment, technique, luck and hard work" (p.745). Nevertheless, they also fall into the trap of writing that "women faculty members and administrators can serve as role models and counsellors for women students" and then go on to describe a series of *mentor* activities. They write of women giving careers advice to students undecided on majors and - of course - advice on how to combine career, profession, family and children (advice not offered to male students). This is not role modelling but active counselling which forms part of mentorship.

Clark and Abron-Robinson (1975) make the same decisive assertion that "the presence of minority female instructors in minority engineering schools helps to attract more such females ..." without any direct empirical evidence or references. Their only recorded evidence in this article is, again, of *mentorship*. "It has been our experience that the minority student seeks out the ear of the minority female professor for advice about scholastic problems, scheduling problems and family or personal problems" (p.35). Dresselhaus, one of America's few women Professors of Electrical Engineering (at MIT), writes anecdotally that she is convinced that the visibility and availability of (female) role models is a resource for raising the aspirations and self-confidence of women engineering students. But the examples she cites are mainly of *mentorship and not of passive role modelling.* "I have helped them come to grips with psychological hangups ... women students really want to know how (in very specific terms) I manage to maintain an active professional life together with a happy marriage and family" (Dresselhaus, 1975, p.33). Dresselhaus reinforces this in mentorship terms beyond her Professor/student role: "I am asked almost daily by some woman or other (often not connected with MIT) for professional counselling advice on technical careers" (p.33). Neither researcher records any empirical evidence to support their conviction.

Purdue University in Indiana is one of the most successful American Universities to attract women to engineering, with a longterm multidimensional strategy throughout the 1970s and early 1980s. Purdue University has increased its female recruitment into engineering over ten years from 47 in 1967, and 817 in 1976, to over 1,000 women engineering undergraduates in 1979. While the Purdue Model Program for Women entering Engineering (funded partly under the Women's Educational Equity Act) needs to be seen as a whole, one of the core elements is the use of lecture discussions of career engineering and contemporary problems by women lecturers *explicitly chosen as role models* (happy, married, successful etc ...) to first year undergraduates (Daniels and Lebold [1982]; Byrne [1985]). What the Purdue reports have not done, however, is to separate out the possible actual influence of the role model factor, from all of the other elements in the overall strategy. In particular, the instances cited of the positive effects of the alleged role models, were in fact examples of the *mentor* process. The visiting women engineers talked and advised about dual-role problems (reconciling career with home responsibilities).

One American review of a wide range of affirmative action programmes in vocational education concluded that there were three overriding qualities which teaching staff needed for sex equity programmes to be successful, one of which was "an ability to serve as a role model for female participants" - and the report assumes as a given, that this means a same-sex role model, without providing any empirical or theoretical basis for this (Wheeler, Jeanetter, et al, 1979). A second similar review of special programmes for women to enter science, maths and engineering in schools, colleges and higher education, also notes the building in of active female role modelling in many (indeed, most) projects (Aldrich & Hall, 1980). But a fairly sophisticated literature search has failed to reveal any substantial follow through evaluation to check

(a) whether female enrolments increased, and sustained that increase; or

(b) whether, and if so how, same-sex role modelling was at all influential in this.

That is, so far the assertions of a relationship between role modelling and recruitment as such, appear to be based on conviction and repetition and not on evidence: the Snark Syndrome.

Same-sex or Cross-Sex Models?

The issue whether a role model needs, indeed, to be of the same sex for the process to operate successfully as a policy mechanism, continues to be controversial. The issue hinges partly on how far, by the time girls reach adolescence, they are seen to be able to identify strongly enough with an adult of the opposite sex, to see themselves as changing their curricular choices or behaviour patterns to emulate the opposite-sex model, or how far they need a same-sex model.

At the University level, Goldstein (1979) looked at the effect of same-sex and cross-sex role models on the subsequent academic productivity of scholars. She claimed that scholars in the two same-sex conditions (female PhDs with female supervisor, male PhDs with male supervisor) published significantly more research than did scholars in the two cross-sex conditions. The results need to be interpreted cautiously; a causal relationship between supervisor/student, sex and productivity cannot be proven. Nor can we know whether and how a role modelling process takes place without study of individual cases. The data raise interesting issues. One is clearly the mentor hypothesis that the female PhD students with female supervisors published more, not because of a warm empathetic identification with the supervisor, but because the female supervisor gave more practical help and mentorship both in the form of Martha White's "biological library" process and direct help in drafting and placing articles. That is, the same-sex empathy and the similarity in styles of discourse and of ethics and "message" in terms of Gilligan's (1982) research of which we spoke earlier, led to more positive and practical help in supervision because of cultural consonance. To validate the hypothesis, this would need careful empirical study in contrasting disciplines; one in which the women supervisors were a critical mass and one in which they were nontraditional. This is because of the possibility (even likelihood) that the latter had moved nearer to the male norms of discourse and behaviour in order to survive in an ecological niche which was dissonant to their previous cultural educational style.

Another much cited study by Gilbert, Gallessich and Evans (1983) is equally imprecise. It identified role modelling most vaguely as "an active relationship between the modeller and the model in which factors such as perceived similarity in values, personal characteristics and life-style are crucial" (p.599), but did not clearly define the relationship at all. The researchers asked students in a Psychology Department to identify a role model in the academic staff "in regard to their own professional development and goals" in these terms. Gilbert et al concentrated on whether graduate doctoral University students (N = 80F and 77M) who identified same-sex models, would differ from those who identified opposite-sex models, in their self evaluations of competency, stress and satisfaction. They attempted also to measure for work commitment and career aspirations, self-esteem and psychological masculinity and femininity, and asked whether males and females differed in choice of models; whether students with same-sex models would report a higher competency score, report higher satisfaction and less stress and conflict. The authors report that although only 10 per cent of the academic staff were female, 35 per cent of women students identified a female professor as a role model - but 65 per cent of women, a male role model. By contrast, of the men, only 15 per cent identified a woman role model and 85 per cent a man. The researchers report that while male and female students with same-sex role models "showed no differences on the measures of work commitment, career aspirations, self esteem and masculinity", by contrast, "female graduate students identifying professors as female role models viewed themselves as more career oriented, confident and instrumental than did female students identifying male role models". But we do not know whether it was the students who already had higher aspirations and confidence who selected the women to interact with, or already had similarities of lifestyle (professional high status background). The anonymity of the questionnaire also prevented a check on the students' actual achievement, and the study does not enlighten how or why (or indeed, whether) role modelling was influential in terms of academic choices and achievement. Nor does it identify the process through which the female students reached the greater degree of instrumentality and career orientation. Was it empathy and self-identification - or greater practical supervisory support (which is, of course, mentorship)?

Gilbert's later (1985) study of a small sample of American psychology students (N = 33F + 24M graduate students) concluded that female students valued lifestyle and values more significantly in a role model than the male students surveyed. She argues that the same-sex role model therefore needs to show that they can "effectively integrate professional and personal roles" (p.121). Her study, however, still is (like many which are frequently cited) limited in sample, scope and discipline, and concedes what this writer considers a critical flaw: "participants in the present study may have differing views of what constitutes a role model" (p.122), because this was not sharply defined in terms of our three phases; or indeed, defined clearly at all.

Seater and Ridgeway (1976) studied 269 college students (112F +157M) in the context of role models and other adult influences on college women's aspirations. This report defines role modelling both by Kemper's reference group process, and as a process in which achievement by the role model must show successful combination of career, marriage and family (p.50). Seater and Ridgeway do concede that aspirations are influenced also by other significant adults who may not be role models (same-sex or otherwise). They record that the 44 per cent of women students who identified a role model (but by a process that the researchers do not record fully), "did have significantly higher degree expectations and were significantly more likely to have plans to enrol in graduate school" than the fifty-five women students who identified no role model. But the research report is unclear as to whether, and if so, how, other variables of influence were controlled or eliminated in favour of role modelling. More important in this study is the reported result that "perceived encouragement from male faculty members was directly related to higher degree expectations, plans to enrol in graduate school and a more favourable attitude for both male and female students" (p.58). The study also recorded that "one of the groups perceived as least supportive, was male faculty" (p.61).

Douvan's (1976) analysis of whether, and if so how role modelling operates in women's professional development is also mainly theoretical, and locates more in the "breaking-the-stereotype" phase. The women at Vassar who were both "committed intellectuals and scholars at the same time that they had husbands and children and led rich full family lives" (p.8) provided Douvan's colleagues with the possibility of giving "serious thought" to acquiring a profession. By contrast, Douvan herself perceiving (as a role model) an unmarried female social scientist of international reputation who had "great charm ... unambivalent self assertion and a gentle beautiful personhood" (p.9), was able to use her to discredit prevalent social assumptions that single women must be unhappy and unfulfilled, or could not have *chosen* a career over marriage. What is not clear in either case is how the empathetic self-identification took place (if it did) or how influential it was in their curricular or vocational choice, relative to other factors.

The ambivalence grows when we recognise that a *supportive* role model (of either sex) has been seen by college students as more important than a same-sex role model as such (Almquist and Angrist, 1971). In a later study, however, Angrist and Almquist (1975) still interpret their available evidence to conclude that female students are more likely to major in a Department where there are female lecturing staff. In Tangri's study (1972) a supportive boyfriend was seen by some students as at least as important as a female member of staff, for those looking at nontraditional disciplines.

A new international study of women who teach in Universities in Britain, France, Finland, and West and East German, provides further detailed and complex evidence to challenge this (Sutherland, 1985). Most of the women interviewed had reported that they had benefited from male mentorship because there were very few women in powerful positions, as well as because they encountered genuinely supportive male academics. Even in Finland "many of the women owed their academic progress to the support and encouragement given by male professors" (p.70). But Sutherland's interviewees tended to confirm our UQ WISTA differentiation between degrees of nontraditionality: what we described as "the rubric of exceptions", often applied. In Finland "women who had been the first female assistants or professors in their subject areas had certainly met with a considerable amount of social comment: *they had been regarded as oddities*" (p.70, our emphasis), a view of unusualness they are recorded as having had to "live down". Throughout Sutherland's scholarly international study, two concurrent and recurrent themes are recorded: the debt the successful women owed to mentorship from both sexes, but also widespread consistent male prejudice and attitudinal barriers in the institutional environment. (Her evidence on and analysis of the effect of the dual role, family:work conflicts and the child care factor are convincing in locating these as continuing barriers, but are outside the scope of this study).

Role modelling has also been discussed predominantly in relation to its effect on the same-sex student rather than opposite-sex student. Its value in the breaking-the-stereotype phase is arguably equally influential where male students see women in nontraditional roles, which can also alter *male* attitudes and help to liberalise them. A female senior lecturer in computing at one of the Institutes of Technology we surveyed (where women were less than a third of all students in the Institute and just over a quarter of undergraduate computer science students in 1985), attended one of the UQ WISTA group interviews. That interview also confirmed the thrust of Spender's (1980) findings - the two minority women found it difficult to obtain air time in the discussion. The lecturer wrote:

> *"Apropos of role models. I didn't get a chance to say anything on Wednesday but I had all my children while I was a lecturer at the Institute. The students became quite used to seeing me pregnant, carrying babies in pouches and breastfeeding in meetings and seminar rooms (they were at the Institute creche). I think actually it had a much greater effect on the males than on the females. Presumably they were used to thinking of mothers as people who stayed at home and one who combined a demanding job was a revelation, judging from the comments I received from many of them."*

Again, it proved difficult to trace in our literature search, any readily available, major and/or longitudinal studies which (when controlling for other factors) supported the ubiquitous and unshakeable belief that not only role modelling is an effective policy mechanism but that the models need to be the same sex. What evidence was there that where same-sex role modelling was really present, it actually then changed girls' vocational behaviour?

Does Same-sex Role Modelling Induce Vocational Behaviour Change?

We have argued above that to validate a hypothesis that the presence of female role models would persuade girls and young women to make more nontraditional choices, research would need to identify much more closely the processes of self-identification, of acceptance of non-typicality or perception of sexnormality, and of the direct application of these to aspiration, motivation and curricular choice. Is there any evidence to support, unambiguously, such a clear cause-and-effect relationship between the modelling process and actual persistance in nontraditional choices?

Bell (1970) looked at this in occupational terms and suggested, for example, that there are two different processes: interaction, and the personal identification of the younger person with the role model. Bell's sample was, however, of 101 young adult American males in 1961-2 when they had been out of school for seven years; another "male-as-norm" project. Bell, moreover, defined role model as "any person to whom a subject felt himself to be similar (or dissimilar) or whom a subject wished to be like (or unlike) or whose values the subject claimed to have adopted (or refused to adopt)", a definition decidedly lacking in precision. Bell argued as a result of his small study that subjects who possessed a most positive occupational and personal role model reached a higher occupational level, with better pay and conditions, were more "successful" in career development, than those without, after seven years of work. His reported research, however, does not record whether, and if so how, he controlled for other key variables like ability or social class, type of occupation or qualifications on leaving school; and the sample was all male.

To the extent that most widely reported researchers in this field have raised the issue of *interaction* as well as identification, we are strengthened in our view that much of what is reported is in fact interactive mentorship and not the modelling process, and that it is this which is the important influence.

Some of the seriously and frequently cited studies also represent samples too small from which to generalise. In a rather vaguely reported small study of a medical school, Roeske and Lake (1977) note that women students recorded a *perceived* lack of women role models in their first two years, but third and fourth year female students said they did not need them. The study was not, however, longitudinal and it is not, moreover, reported whether the first and second year women, when they in turn became third and fourth year, had also ceased to see role modelling as important. Nor do the researchers identify where the women who reported a lack of role models actually were in aspiration, motivation or achievement in their later years (as compared with earlier), or what the perceived difference would have been, had they seen female role models ahead. Shapley (1975) saw a need in America for every college student in science to have the support of an interested Professor to gain entrance to a graduate Department and for publication of work. Strauss (1978) doubts that the sponsor or mentor will in fact be available to female students unless the sponsors (usually male) recognise as legitimate, a woman student's commitment to a career rather than to full-time motherhood. Hence, yet again the question of attitudinal factors meshes with modelling and mentorship.

Some reported research is even more distant from empirical evidence of actual behaviour changes. Thus, Tidball (1973 and 1974) postulates that women lecturing staff serve as role models for women on the basis of an analysis of Who's Who in American Women, 1966-71. Graduates from women's colleges (selective and less selective) were, on her analysis, twice as likely to become achievers than women from coeducational institutions, on the basis that the number of women achievers increased directly in relation to the ratio of women Faculty to women students. This is shaky evidence on which to base a theory that the presence of women staff will increase the number of women students *in itself*, and is a questionable technique. Entry in a biographical index depends on both nomination and the cooperation of the potential entry. Biographical dictionaries are selective (in both senses of the word) and incomplete. Oates and Williamson (1978) reworded Tidball's study and looked at women in Who's Who in American Women, 1974-75. They concluded that it was the high selectivity of entry to those women's colleges from which high achievers came, which was the more influential factor, and not the presence of women staff as such. That is, high socio-economic status and higher innate ability were more influential than the single-sex environment and women staff as such.

Later studies confuse the issue further. O'Donnell and Anderson (1978) found no evidence at all that women students had even been able to identify specific lecturers or teachers who had influenced their choice of major by a role modelling process. Basow and Howe (1980), by contrast, were certain that their evidence showed that having a female teacher was important for the career decision of female college students - even though they only achieved a positive correlation when they reran their abortive first analysis, by balancing the number of male and female students in each group.

Typically, female role models have also been seen to need to be superwoman if they are to inspire behaviour changes. Strauss identifies societal attitudes or "sex-role ideology" which lead to sex-differentiated teaching, as a major barrier in American education, and sees one strategy as the importation in the careers programmes of schools and colleges of "a woman scientist or engineer from the community who is happy, successful and whose work may be perceived as important enough to be an alternative to traditional female careers". Strauss asserts a preference within the female role model range: *"The ideal role model for any girl is a career oriented mother who is happy and successful in both employment and family endeavours"* (Strauss, 1978). Bowling and Martin (1985) cite four model strategies as necessary to increase women's participation in existing forms of science and democratising science, among which the use of same-sex role models is seen as part of an overall programme of publicity and networking. They see a need for "successful women scientists to be widely seen as successful and as desirable models to be followed by other women - and to be accepted and admired by men". But they also see the existing role models as likely to be honorary males because only these will be likely to breach the barriers of hierarchy, instrumentalism and elitism (p.314).

Almquist and Angrist's (1971) research report on role model influences on the career aspirations of college women, is well argued, but is based on "a longitudinal study of one class from the women's college of a small, private, coeducational and technologically oriented university" (p.267). The researchers did not distinguish the professorial or occupational role models by sex. They concluded, inter alia, that "for women, the importance of role models lies in their explication of a life style which incorporates work with family life". If this were exclusively true, it would imply that single career women are unlikely or unsuitable or ineffective role models - a view decisively rejected by some key careers and counselling staff in our survey institutions. Almquist and Angrist also identified that the "career-salient" women, or those who had deliberately chosen a long term occupational lifestyle (and not a broken career or one terminated on marriage), were the ones who "had future mates who fostered their work plans" (p.277). But the processes investigated in this study (as in other replication studies) were not the relationship between female *identification* with a role model and subsequent nontraditional motivation and choice, but student evaluation of the extent to which the alleged role models "provide a technical explication of how various jobs are performed, ... how positive extra-work relationships develop between role model and neophyte" and so on. Once again, these are *mentor* activities.

Douvan (1976) describes the task of minority women in academe as "to become socialised to the higher status world without losing one's identity and touch with one's own history" (p.11). One choice she perceives as available is to become like the dominant group and abandon one's past which as a psychologist she defines clinically as identification with the aggressor (p.11). Alternatively, she lists the abandonment or de-emphasis of competence, or "a trenchant continuing effort to integrate professionalism" and what she calls "feminine goals".

One of the more transferable studies is that of Erkut and Mokros (1984), who questioned students in six American liberal arts colleges, five coeducational and one women's only college. The 723 students who identified a professor they considered important for themselves, identified the impact by commitment, skills and personal qualities. The researchers concluded that female students neither gravitated towards nor avoided female role models but that male students avoided female models and identified with high status powerful males. The Erkut and Mokros study raises, however, a related issue, that of same-sex role models and single-sex institutions. Within the sample, women at the single-sex college were perceived to be more academically successful, more successful in relation to male and female peers, and more planned to go on to postgraduate study. Without knowing more of the women's college, we cannot tell whether the modification of results when controlled for ability and social class applies also here. For example, in Tidball and Kistia-Kowsky's (1976) study of American women PhDs since 1920, they concluded that the seven elite women's colleges produced proportionately more female PhDs than mixed colleges. But the elite colleges had a much tougher selection process, and their students might reasonably be expected to achieve relatively more highly than male and female peers elsewhere.

Selectivity and social class are not the only variables which skew the research on how far same-sex teachers can act as a positive influence to encourage girls' nontraditional choices. Harding's (1983) review of science education for girls suggests that it may in fact be partly that "teaching style and individual behaviour may be more influential than the sex of the teacher". When Welch and Lawrenz (1982) looked at the characteristics of male and female science teachers in a fourteen state region of USA, they did identify several significant differences between the two groups (for example, female teachers rated higher on measures of interests in science and receptivity to change, male teachers higher on science knowledge). Eggleston et al (1976) suggested that teaching style was highly correlated with sex, more women science teachers tending to use pupil-centred enquiry methods and more men using problem solving teaching-centred, teacher-initiated styles. The former style used by more women teachers, was seen to be more effective in retaining girls in physics and chemistry, in the British schools surveyed. Stasz, Shavelson and Stasz (1985) examined another aspect of teaching style - the use of microcomputers to teach Maths and Science. In a survey across sixty classrooms in forty-nine schools in twenty-five districts in California, they concluded that both female and male teachers provide leadership in the microcomputer movement, have relevant training and experience, and "present equally viable role models", despite their observations that twice as many boys as girls take computer programming in American high schools, and that boys monopolise equipment where classroom control is lax and that war scenes and physical adventure games dominate in software. Among the teachers surveyed, although males were more experienced in experimental measures, "there were no differences among interviewees' ratings of male and female teachers". The researchers note that "our data could not address one important facet of the role model approach, namely, whether these noted computer teachers were sensitive to sex equity issues in their classrooms. *The sex of a teacher is not a predictor of nonsexist practice*" (my emphasis). The author confirms the need to determine the relationship between gender and non-sexist teaching practice. It cannot be automatically assumed that top women support and encourage other women.

In summary, the research we have reviewed and the diverse and often contradictory findings and conclusions reported in both research and project literature, did not provide a neat and unambiguous basis for a finite scientific conclusion. Nevertheless, we saw a number of themes, issues and hypotheses as emerging rather more clearly in this overview.

We now record final working hypotheses which we believed could be supported. The previous research we have reviewed provided a reasonably consistent and cross-national basis (but not decisive empirical evidence) for supporting the hypothesis that

> **same-sex role modelling is an important influence on breaking the stereotypes of ascribed masculinity and femininity in the vocational setting of curricular choice and of career aspiration.**

That is, the research so far supports, on balance, that if female role modelling is visibly used to ***break the stereotype*** of the exclusive masculinity of the image of maths, science or technology as higher education disciplines, it is likely to be reasonably effective. How this is done, in terms of policy mechanisms, is another matter, and the last section of this Chapter discusses a major shift in policy for future projects receiving public or institutional funding which intend to incorporate conscious same-sex role modelling.

We believe that our critique of earlier relevant research and its weaknesses justify a second conclusion. This is that

> **the basis for arguing that the mere acquisition of more female staff in a given discipline or occupation would, in itself, result in an increase in female students and trainees because they have been allegedly inspired to make nontraditional choices by simply seeing female role models, is not founded in either well grounded rigorous theory, or in sound empirical evidence.**

We set out therefore to look at both the patterns of participation of women students and staff in our ten institutions and across the survey disciplines, to see how far our data supported traditional role model theory, and how far our replacement negative hypotheses was supported. That is, we used Glaser and Strauss's grounded theory approach to test hypotheses in this area.

THE UQ WISTA DATA INTERPRETED

It seemed to us from the start, tolerably unrealistic to use role modelling theory as a policy mechanism in the first place, in view of the limited overall numbers of women staff in most scientific and technological disciplines. Even if the somewhat doubtful expectation that in theory the presence of women staff would result in students working through all three stages of role modelling, were valid, the process could not operate in practice unless

(a) there were *enough women staff* in the relevant disciplines to provide choices of role models with whom girls and young women could identify and use to strengthen their nontraditional vocational choices; and

(b) the women staff formed a sufficient *critical mass* in each discipline or "ecological niche" to alter the image of the discipline to one of either sexnormality for women or to sexneutrality.

We expressed some scepticism that the mere visibility of women academics would be correlated with higher female enrolments. One logical first step was therefore to plot the proportion of women staff in each survey discipline and to match this with the proportion of women students in the same discipline at undergraduate level in all of our survey institutions. If the traditional role model theory were true, we would expect to find a consistent pattern that higher female enrolments occurred in the disciplines with higher numbers and proportions of women staff: and we did not.

Chapter IV sets out the main patterns of female enrolments by discipline, level and institution for the survey year of 1985. We give here, the numbers and proportions of female students and staff by discipline, in the context of both access (undergraduate numbers) and progression (postgraduate numbers).

The UQ WISTA Statistical Evidence

In **Physics**, female undergraduate enrolments averaged only 17 per cent across the ten institutions. The institutional range shows considerable interinstitutional differences. It will be seen from Table 5.1, however, that the institution with the highest proportion of women staff in physics is that with one of the two lowest proportions of female undergraduate enrolments.

TABLE 5.1

PHYSICS: 1985

Institution	Undergraduates Women Students		Female Staff	
	Number F	F % Total	Number F	F % Total
UNSW	21	20.2%	5	8.0%
NSWIT	28	13.9%	-	-
UQ	77	19.0%	-	-
QIT	9	16.7%	1	4.3%
MON	81	20.5%	1	5.2%
RMIT	12	9.8%	7.1	19.7%
U Ad	75	18.8%	-	-
SAIT	4	8.7%	-	-
UWA	187	23.0%	2.5	12.6%
WAIT	5	15.0%	-	-

Five institutions had no women academic staff at all in Physics, but two of these recruited women students at just above the ten-institutional mean.

Chemistry recruits at more than twice the Physics average, that is an average undergraduate female enrolment of 38 per cent across our ten institutions, and would therefore rank as *sexnormal* on the Byrne fourpoint scale of sexnormality and nontraditionality described earlier. If role modelling were an influential factor, we would expect to see a higher proportion of women staff therefore. But there were, in fact, fewer women lecturers in Chemistry than in Physics in 1985.

TABLE 5.2

CHEMISTRY: 1985

Institution	Undergraduates Women Students		Female Staff	
	Number F	F % Total	Number F	F % Total
UNSW	44	35.0%	2	3.0%
NSWIT	85.5	40.1%	-	-
UQ	285	47.7%	-	-
QIT	50	29.9%	-	-
MON	376	44.1%	0.5	1.5%
RMIT	150	46.3%	3.2	8.8%
U Ad	260	35.9%	1	4.3%
SAIT	* 41	30.1%	2	10.0%
UWA	335	40.7%	-	-
WAIT	32	30.0%	-	-

* Includes Chemical Technology and Microbiology

In 1985, three institutions had a female enrolment of over 40 per cent and no permanent women academic staff of Lecturer and above; Monash University had 44 per cent students and only 1.5 per cent women staff. The numbers were peripheral. SAIT, with 10 per cent women staff in Chemistry, has the highest proportion of women staff and one of the lowest proportions of women students. Women are not a critical mass of lecturing staff in this subject; but Chemistry recruits a higher percentage of women undergraduates than most other sciences.

Mathematics recruited in 1985 a female enrolment which was highly variable across the ten institutions but averaged 35 per cent, or twice the mean for physics and slightly below the mean for Chemistry. Even allowing for some inflation of the female Maths students figures at Monash and Adelaide, the proportion of women staff is certainly generally higher than in either Physics or Chemistry - but within the discipline of Mathematics there is no consistent pattern.

TABLE 5.3

MATHEMATICS : 1985

Institution	Undergraduates Women Students		Female Staff	
	Number F	F % Total	Number F	F % Total
UNSW	80	38.3%	4	6.0%
NSWIT	58	40.8	-	-
UQ	400	28.8%	4	10.8%
QIT	51	38.9	3	12.5%
MON	691	43.4%	3	7.2%
RMIT	108	32.1%	4.3	13.9%
U Ad	495	31.4%	5	12.5%
SAIT	(not offered at undergraduate level)			
UWA	640	31.0%	6.5	17.6%
WAIT	41	28.0%	-	-

For example, University of Western Australia had the highest proportion of women staff in Mathematics but one of the lower proportions of women students. Conversely, Monash University had the highest proportion of women students but almost the lowest proportion of women staff.

When we look at those disciplines where women are in a clear majority, moreover, and the discipline is either *sexneutral* or *sexnormal* for women at the level of female undergraduate enrolments, we find that most had no women academic staff at all.

In **Biotechnology** women were 63 per cent of undergraduate enrolments at WAIT, 55 per cent at NSWIT and 34 per cent at RMIT, all of which had no women academic staff in this area; and at the University of New South Wales, women were 52 per cent of undergraduate Biotechnology students and 22 per cent (two staff) of academic staff in the area. In **Biochemistry** and **Microbiology**, undergraduate female enrolments averaged 55 per cent and 59 per cent respectively or well into the sexnormal for women category. But in Biochemistry, four institutions had no women academic staff at all in this discipline; in a further three, women academic staff were fewer than 15 per cent of the total; and at the University of Western Australia, where women academics represented 25 per cent of the total Biochemistry staff (one of the three highest proportions), the female student enrolment was in fact the lowest of the six institutions where this discipline was offered. The position in Microbiology was equally uneven.

TABLE 5.4

MICROBIOLOGY: 1985

Institution	Undergraduates Women Students		Female Staff	
	Number F	F % Total	Number F	F % Total
UNSW	50	65.8%	5	36.0%
UQ	136	59.9%	2	16.7%
MON	95	59.7%	1	4.3%
U Ad	90	61.6%	1.8	21.7%
UWA	99	47.0%	2	19.0%

While the student figures were relatively constant, the staffing profiles were not and showed considerable inter-institutional variations.

These relationships or nonrelationships have been plotted for all the survey disciplines, and women staff are even fewer in the technological and applied disciplines. Nor was there any coherent or consistent significant relationship between relatively higher female enrolments in certain subdisciplines (eg chemical as distinct from civil engineering) and the presence of women staff, in any technologies.

The UQ WISTA analyses lead us to conclude that in our survey,

* scientific and technological disciplines which have relatively higher proportions of undergraduate female enrolments do not generally have a higher proportion of female academic staff;

* scientific and technological disciplines which have relatively higher proportions of female academic staff do not generally have a higher proportion of female undergraduate students;

* in a number of disciplines in several of the survey institutions, the *highest* female student enrolment in fact coexisted with the *lowest* proportion of women academic staff in that discipline in the same institution; and vice versa;

* there was **no traceable consistent pattern** of a first level statistical relationship between the female proportion of student undergraduate enrolments and the proportion of women staff in the same discipline in the same institution.

We do not, therefore, find any data to support traditional same-sex role model theory in relation to initial access to nontraditional science and technology; and therefore conclude also that

> **the UQ WISTA staff and student data in the disciplines in this survey do not support a hypothesis that increasing the number or proportion of women academics in a given academic discipline, will necessarily and by itself, increase subsequent female enrolments at the level of first access to higher education in nontraditional science and technology.**

This is not to say that same-sex role modelling is an irrelevant factor to the question as a whole. It may well be partly more relevant to progression than to access. It may be also useful as part of a cluster strategy involving several factors simultaneously. It can still help in the breaking-the-stereotype function. Because of its possible influence in progression, we therefore checked out the possibility of a statistical relationship between the proportion of women staff in each discipline and the proportion of women in the **postgraduate** masters research and doctoral research student body in the same discipline in the same institution.

In no discipline could we find a majority of relevant institutions (Institutes did not offer doctoral programmes) which could show **consistently** higher proportions of female postgraduates and higher proportions of female staff, **in the same discipline**. There was no traceable consistent pattern or relationship. We concluded that

> **there was no consistent pattern of evidence from the UQ WISTA staff and student data in this survey which supported a hypothesis that the mere visible presence of women academic staff in a discipline, is causally related to the female proportion of postgraduate research students in the same discipline in the same institution.**

THE RECEIVED WISDOM: THE VIEWS OF ACADEMICS IN UQ WISTA INSTITUTIONS

Not only did we find neither a basis in previous research or data nor any statistical evidence in the UQ WISTA survey to support traditional role model theory. We also found that, nevertheless, this was one of the most deeply embedded but unfounded convictions held by the scientists and technologists who attended our group interviews, and/or who wrote in response to our circulated discussion papers.

The discussion papers on role models were circulated to relevant senior academics in the selected survey disciplines in the period March-May 1986. Professors, Deans, Heads of Schools and careers guidance and counselling staff were asked to come to group interviews (or to send a representative) ready to discuss the issues raised, "both in relation to your own discipline and your institution as such, and in the light of this written research summary". They were also asked to write after the meeting to the Director of the University of

Queensland WISTA project either with further (or reconsidered) views or on possible future action by institutions or government, in relation to these two factors. The Discussion Papers defined the factors, described the most relevant research and ended with four questions to be addressed. In relation to role modelling, we asked

(a) *Can you see a full time or part time woman in your discipline who you think is performing one or more of the positive functions of a role model? What is her level or grade? Can you assess her likely influence on women students?*

(b) *Can you suggest ways, in your discipline or area, in which you could (or do?) create same-sex role modelling as a process of "normalising" the discipline for women, by bringing in external women?*

(c) *Given the agreed principle that only equally qualified women be appointed or used, what part could you see the issue of positive role modelling playing in the future policy of this University or Institute? What kinds of options do you think are both feasible and professionally acceptable?*

(d) *How influential do you think this factor is?*

While we asked primarily that those attending the interviews (when the context of the questions being studied was aired) should also respond in writing, Deans, Heads etc were also encouraged to circulate the papers more widely and to invite written responses from any academic interested to do so. It is clear from the replies that in many disciplines in all ten institutions, senior staff failed to explain the context or the issues, or to supply the previously circulated introductory documentation on the UQ WISTA Policy Review project at the time when they circulated the Discussion Papers. These had been drafted and used in the expectation that the respondents would have seen the written outline of the aims and purposes of the UQ WISTA project sent to all attending the group interviews, and would have heard the contextual discussions in the interviews. In practice, this did not happen. Many who attended the interviews did not respond in writing; many who wrote in, acquired the Discussion Papers by varied means and lacked the contextual background. In our field analysis of the main essence of the responses, we have accordingly differentiated between those attending the interviews only, those who both attended and wrote, and those who wrote without the additional context of the interviews. We deliberately did not prescribe access to the material, nor restrict input to a controlled sample, because we wished to test out whether different Departments or disciplines would vary in their approaches, reflecting a different cultural ecology. Nor did we consider that the issues being explored were susceptible to reduction to 5-point graded questionnaires. The questions were expressly phrased to elicit qualitative, non-numerical, non-formula answers and clearly asked for opinion and judgement, because these in fact are what determines the institutional attitudes and climate.

We noted with interest that generally, the more instrumental the discipline (Maths, Physics, Engineering), the greater the difficulty respondents tended to find in handling questions not reducible to a formula. Conversely, the more flexible or free-floating the discipline in its organisation and structure, the more discursive, qualitative and contextual the respondents' answers or contributions.

Widespread Belief or Conviction but Confused Understanding of Role Modelling

We found deep conviction based on no evidence whatever, to be widely evident both in the interviews and in the written responses. Both in the group discussions and in most of the letters, most academics who commented on role modelling had accepted as totally unquestionable, an unsupported assertion that the presence of women role models would increase enrolments. They failed either to distinguish between the stages of the role modelling process or to justify the quantum leap from students seeing visible women, to students altering vocational behaviour because of this. In particular, we found frequent evidence of the strength of the belief as a panacea for every kind of problem. There was, for example, an unselective belief in the equal validity of modelling as an access, and as a retention, influence.

A female University lecturer in civil engineering wrote that of the 5 per cent of their students who were female and who she saw as underachieving, "we have an undesirable female show-cause and dropout rate. In terms of these facts I believe role models are vital" (Letter, University). In this, she had an unsupported belief in modelling as an influential retention factor. In the same discipline, a colleague from another institution echoed the assertion, but as an access factor: *"I have been persuaded that it would help young women to decide to enter engineering if there were women academics on the staff of Engineering Departments"* (Letter, Civil Engineering, Professor).

Among the more elliptic responses, some simply assumed that women who were brought in, did spark off a role modelling process simply by their presence, and that same-sex models would automatically also mentor students.

> *"We have recruited (X) specifically for this, a (female) B.App.Sc. in Geology and Biology ... as a parttime teacher and as a mentor. Role modelling is very influential. It is most negative when no role model is available (but) when several are available, further additions are of less value." (Letter, Geology, Institute of Technology)*

Most of the positive evidence or opinion did support the usefulness of phase one of the process - the breaking-the-stereotype phase:

> *"The School of Engineering currently has 3FT and 2PT women staff. They are all performing as role models and are achieving a small but significant break in the stereotype of engineers ... At the moment we are at the stage that males must perform the mentor role for new female members of staff." (Letter, Engineering, Institute of Technology)*

The "visibility theory" (simply seeing women will encourage girls to make nontraditional choices) was held by many, whom space does not permit us to cite in full.

A Maths lecturer, in answer to question (a) of the Discussion Paper, wrote *"Yes; Tutor; they (students) are able to see someone female in a mathematically orientated career which has previously been male-dominated"* (Letter, Applied Maths, University), without, however, developing in what regard students would change as a result of seeing a nontraditional female. A (male) Professor of Biochemistry questions whether there would be any influence beyond the first phase: *"There are two fulltime women in my discipline who are providing role models ... their primary role is to indicate to both male and female students that women can succeed in my discipline ... I think the role model is not as important today as it was some years ago"* (Letter, University). This respondent also assumed further, however, in his extended answer that the role modelling process took place merely because his colleagues were visible; phase one only of the process. Other submissions replicated this constantly.

Where the belief in this process persisted, it was sometimes linked with a recognition of its impracticability as a policy. In the previous section, we questioned the realism of a policy for same-sex role modelling if the women staff simply were not there or even in the pipeline. This was graphically echoed for metallurgy:

> *"This Department acknowledges the importance of positive role models ... the difficulty is to find the equally qualified female in Metallurgical Engineering ... There are no external women available ... This factor is very influential but in order to have a chicken you must first have an egg." (Letter, Institute)*

What is important to note here is that the importance of this factor is strongly reiterated even though the impossibility of achieving it as a policy mechanism is simultaneously conceded.

Who is a Good Role Model?

There was, however, marked disagreement on who was or was not a good role model. On the one hand, many saw a need for successful, married women to role model. Others saw it as important to have happy, successful, fulfilled single women role models; girls needed to see that marriage was not Nirvana. But in one group interview, a Careers Adviser commented in relation to the Discussion Papers that

> *"I could see that the stuff about role models and mentors just had to be absolutely right, but what I thought hadn't been said was the fact that what role models there are tend to be women who don't have families, and so that the extra message is passed on that not only is it possible to aspire, but there's a price attached to it. But men are not asked to pay that price, and so there's in fact a sort of hidden agenda about what role models are." (Interview, University).*

This comment echoes the research evidence we referred to earlier, describing projects in which the current definition of role modelling was based on women's perceived need to show success in the dual role, but men's complete freedom in this respect. The "Superwoman" aspect, the Archangel Gabriel of role modelling was clearly a further problem. Of those who had clear ideas as to which women would visibly encourage others, the following produces a depressing level of high expectation of female, but not male, achievement in this respect:

> *"Clearly if one can demonstrate to secondary schoolgirls that a woman can be a successful engineer while at the same time being happily married and able to adjust her married life, in cooperation with her husband, in such a way that children can be properly looked after, then the role model is fully useful." (Letter, Male, Metallurgy, Institute).*

No such impossible modelling role is required for boys (a successful male engineer to be happily married, participating in domestic chores, helping to raise children and yet not "neglecting" home or work...).

A (male) colleague from Chemistry commented on the unrealism of such an expectation, and shared our scepticism; but he was in a small minority.

> *"I do not see the presence of a female mentor to be an important factor in aiding progress of women in higher education. I believe role models are important (but) the key according to Strauss is to be 'happy and successful in both employment and family endeavours'. This is difficult for either sex: for female academics in science it is most difficult since success in employment*

> *will be dependent on postdoctoral appointments abroad." (Letter, Institute of Technology).*

And in another interview, an engineering academic noting the absence of people of either sex providing role models to encourage interest in engineering, saw no need for them to be of the same sex, and also doubted the current feasibility of using scarce women engineers as positive models:

> *"Role models, male and female, in engineering and technology are very few and far between and I would suggest to you that as far as women and engineering is concerned, providing role models to children in schools, you could just as reasonably ask about men in engineering providing role models to children in schools. There is an absence on both sides ... there has been a decline in science and engineering enrolments ... There might be girls out there in engineering, there are, they are our own graduates, but there's no way you would ever be able to parade them as role models. It's just not the way the media operates or that our society operates ... the problem is to expose them ..." (Group Interview, Professor of Engineering, University).*

A female masters student in Physics at an Institute of Technology attended one of the group interviews in 1986. She wrote subsequently that *"the Department has very few role models. Apart from this lack, I do not think that female students are actively discouraged"*, but goes on to write strongly in support of role modelling as an example to break the stereotype. Her evidence, however, shows the conceptual confusion characteristic of most responses: on the one hand supporting, on the other rejecting the notion that same-sex models are needed. A female parttime lecturer at her Institute was seen by her as a role model and "a leading example of what a woman physicist can achieve", and a previous female physics teacher was seen as a strong influence because of extreme capability projecting "enthusiasm, knowledge and commonsense to all her students". But she describes modelling as a generic, not a sex-linked process, in writing that *"Role modelling is very influential in that it is a solid example of an area of interest that one may have. One can evaluate the personal characteristics and to a certain extent what you may be in for, if you make a similar choice ... but I think a role model of the opposite sex can be just as inspiring."* (Letter, Physics, Institute).

We asked that careers and counselling staff be also invited to attend the interviews and to respond to the Discussion Papers, and some of the more complex and diagnostic responses came from this group of staff. One such University group again saw positive same-sex role modelling as important because they believed it showed nontraditionality as attainable. They believed the factor to be constantly and recurrently influential. They saw a direct role for female careers and counselling staff in helping to normalise roles seen as nontraditional, "in the sense of leadership, assertiveness and awareness rather than in terms of our occupational field" (Letter, Careers and Counselling, University). They pressed strongly that cultural factors influencing the situation of aboriginal, overseas and migrant women students be reexamined in the context of the need for same-sex role models to show the "realistic similarity" which the first section of this Chapter highlighted as essential to the identification stage of the modelling process.

In one University, a written response from a male recognised that *"As was pointed out at the meeting, it is difficult for a man to imagine what it is like to have no same-sex role models"* (Letter, Civil Engineering, Male, University). The group interview and discussion paper process were seen by many as usefully airing and clarifying a confused policy issue.

Our overall qualitative analysis of the interviews and replies, led us to conclude, in summary, that in the ten UQ WISTA survey institutions,

* There was a widespread belief in the value of the role modelling process in breaking the male stereotype, unsupported by any scholarly evidence.

* There was, however, widespread confusion and imprecision about what constituted actual role modelling. Examples given in interviews and in writing ranged from mentorship to extrovert affirmative action, and were based on women staff transmitting unconscious messages, but not on how students received these.

* Of those who responded positively that there were visible women in their discipline, almost all assumed that their mere presence, per se, caused a same-sex role modelling process to take place in the female students.

* Those who believed role modelling in higher education to be unimportant, did so either because they believed parents/mothers to be more influential, or because they believed educational factors to be more important, or because there were (and would continue to be) too few women academics in the discipline to make role modelling viable.

* Opinion was sharply divided on the need for same-sex modelling or the equal value of opposite-sex role models. Both views were frequently described in terms of secure belief without any evidential basis for the belief. The strength of the convictions was inversely correlated with the presence of any factual basis.

* Most frequently, role modelling was completely confused with mentorship; and both male and female respondents and interviewees consistently expected more women than

men to act positively to women students in terms of visible example and encouragement.

WHY DOES IT MATTER? THE POLICY IMPLICATIONS

There are considerable implications for policymakers in redefining and resetting role model theory in relation to women's access to science and technology. Review after review of affirmative action projects confirms that trying to use same-sex role modelling as an active policy mechanism continues to be built in to projects carrying substantial governmental funding. Why does this matter?

An Alibi for Male Inaction

Firstly, it matters because as long as men can write off the problem as one of a lack of women role models, they can simultaneously write off their own male responsibilities - either as causes of women's encountered barriers, in the first place; or as potential remediators in the power structures, in the second. Certainly the most obvious explanation for the widespread adoption of the concept of female (same-sex) role modelling as a useful policy mechanism by the men who currently control higher education in Australia in the scientific and technological disciplines, is that as long as male academics can say *"if only we had more women staff, we would have more women students"*, they can place the onus of responsibility for positive change on women staff and students. It obviates the need for men to reexamine male behaviour as a negative influence.

It is significant that almost all of the proposals put forward both in interviews and in writing also involved women in more work, but no traceable expected change on the part of men. For example, in the UQ WISTA survey of institutions, both careers and counselling staff and senior academics (predominantly those in Engineering, Chemistry, Physics and Computing) proposed that the existing minority women in University and Institute Departments should be asked to supervise more field exercises, visit more schools and colleges, go to more careers exhibitions and to counsel more students, all apparently in the interests of increased visibility and a rather vaguely delineated role modelling process. There were no parallel proposals for more work by men.

It should also be recognised that most young women will more readily believe that they can achieve highly in disciplines, when the *men* (staff and students alike) transmit the clear message that it is normal for women to do so; and not because women tell them so. The untypical, confident woman student may be sufficiently inspired by a female role model to emulate her; but the typical young woman will need both male as well as female leadership and male peer accreditation. Only when *male* staff also encourage *male* students to support and accept female students in disciplines seen so far as territorially masculine, are we likely to see substantial change. But one of the disadvantageous aspects of placing female role modelling in a prominent place in policy strategies for change, is precisely that it enables dominant males to continue to see no need to change their style in relation to a "new" clientele: women minority students. The concentration on *same-sex* modelling, diverts attention from the general institutional ecology of the learning environment.

Active Personal Role Modelling Wastes Women's Scarce Time

A further negative effect of the institutionalisation of same-sex role modelling as a policy mechanism is that it adds a fourth role to already overburdened women in a way which is an uneconomic use of their time. Women are now typically and constantly referred to as having a ***dual role***, that is, combining employment and the work of family domestic responsibility; but men who are also husbands and fathers are not so described despite their self-evident parallel status. Proportionately more employed women than men are also widely reported in labour market research as also taking on the personal counselling and caring roles in relation to staff or students for whom they are responsible, in addition to their normal workload; a third and increasingly demanding role. Minority women are now being asked to take on a fourth role, that of frequent waste of precious days, evenings, weekends, often travelling long distances in far-flung Australia, to speak to relatively small numbers of adolescents in schools, colleges, at exhibitions, to fulfil a policy described as in the interests of female visibility. This is despite a total lack of empirical evidence that it has any effect; or what effect.

Academic research in many Western countries has, however, established that women carrying the dual role already have considerable difficulty in freeing an equivalent "spare" time allocation to that of their male peers for writing, research, attending professional seminars. To expect them also to allocate proportionately more time to uneconomic attendance in evenings and weekends at a range of school and college functions specifically to role model, for example, is further to erode that time. Single women are similarly already disadvantaged since in most Western societies, far more of the elderly parents or adult disabled who are dependent and living in domestic rather than institutionalised homes, live with single women relatives. Similarly, more single women than single men, have been shown to be likely to commit themselves to a lifetime's complete domestic responsibility with or without paid employment; but more single males, by contrast, live with a female relative or have fulltime paid domestic infrastructure. It is not argued, of course, that women should not carry an equal responsibility for careers or attendance at necessary functions. But they should not be asked to carry such an additional burden, merely and solely for female visibility, when the function of breaking stereotypes can be achieved more effectively by other means.

A far more effective way to break stereotypes is through the imaging in books, materials and the visual media. But this is precisely what the men who have written and who control textbooks and publishing of educational resources, have refused to do. A review of the research literature on sexrole stereotyping in educational materials has also been completed in the UQ WISTA research, and three principal conclusions can be authenticated cross-culturally and cross-nationally. Firstly, in every country and culture which has been investigated by researchers in postwar years in this regard, books and educational materials, and notably science and mathematics textbooks, have been found to be sex-stereotyped in a way which not only represents male and female roles as mutually exclusive, but is years, often decades, out of date with the reality of the spread of actual female and male societal and occupational roles in the society concerned. Secondly, males and females are rarely represented as successful and happy in nontraditional roles. But, thirdly, when children and adolescents have been presented with books, careers materials or texts which include women in nontraditional roles or occupations, in leadership, in scientific or technological disciplines, the use of these materials has, nevertheless, been effective in breaking sexrole stereotypes and in widening adolescent perceptions of achievable vocational choices.

Similarly, there is credible field evidence from careers educators and teachers that the use of videos showing women successfully handling engineering, management, technician training or business enterprises, is as effective as, or more effective than, personal appearance of individual minority women in widening the vocational perceptions and aspirations of adolescents. Thus a far more effective way in which to achieve phase one of the role modelling process (breaking the stereotype) is to commission videos showing both women and men in nontraditional roles as if they were sexnormal, and to use these widely in the school, careers guidance and training systems. It is, however, of limited value to show successful women mining engineers, physicists and chemical analysts, unless we show their husbands simultaneously supporting them and carrying a full and equal share of domestic responsibility. Grants and project money spent on ferrying untypical women to small functions without the context of an overall strategy to attack sexrole stereotyping in books, careers materials and the visual media, is likely to be a total waste of scarce public money.

Policy Implications for Science Educators and Institutions

But in Australia, and in the UK and USA so far as published project reports in those countries are available, active policies for encouraging girls and women to enter engineering, the technical trades, the applied sciences have been heavily based on traditional role model theory. The Tradeswomen on the Move Australian project in the Hunter Valley and Women in Engineering projects in particular, use minority women to travel far and wide to meet relative handfuls of girls in schools and interact with them. A range of Registers of Non Traditional Women has been produced across Australia from special project grants precisely for the purpose of pressing those nontraditional women to allocate extra time to travelling around being "visible successes", as it were.

The need for women to be equally visible with men in all occupations and roles in which they are represented is accepted, but is a normal mainstream personnel management policy **and should not be seen as an added workload for women in schools and colleges out of working hours.** The simple policy of ensuring that women are relatively equally represented on committees, in decision-making groups and bodies, at public events and forums, and are equally used as delegates to meetings, negotiations and conferences where they are equally qualified, will ensure their visibility much more effectively than artificially constructed personal role modelling techniques at a single event. Similarly, senior women academics and Principals need to be used in the normal way for graduation speeches, public functions and in school ceremonies, where these form part of the institution's ordinary work and do not constitute an extra workload. But schools and colleges can no longer rely on visible female role modelling as an effective influence on adolescent curricular choice (if it ever was). Adolescent students are influenced by the behaviour of both sexes, and in particular, by the attitudes and behaviour of males to females and females to males in their adult community.

Many well meant efforts have also been made in inservice training programmes, to involve more women as role models by "bringing them in from outside". Where women do not exist in a sector or institution, this may have been seen as unavoidable. But a more effective strategy is first to reeducate male staff in the light of the now massive bank of accredited research on girls' equal capacity for maths, science and technology, of the role of sexism and sexrole stereotyping in hindering equal achievement and of girls' equal right to scarce places in these disciplines. Both male and female staff need then to work as a team to reeducate school and college male students in this regard.

The rigorous application of Glaser and Strauss's (1967 and 1972) grounded theory approach to the previous scholarship and to available data in relation to samesex role modelling as a policy mechanism to increase female access to science and technology, results in the necessary rejection of most traditional hypotheses and received wisdom.

One outcome of the UQ WISTA Policy Review research and its different levels of data and replacement grounded theory, is a suggested replacement set of principles and theory in this area. In relation to ***same-sex role modelling, breaking the stereotype***, we conclude that:

- There is still a reasonable, a consistent and a cross-national basis for supporting the hypothesis that same-sex role modelling is an important influence on ***breaking the stereotypes*** of ascribed masculinity and femininity in branches of science and technology, in the context of female curricular choice and vocational aspiration.
- However, change will not occur through mere visible imaging of female success, but through new knowledge, new understanding and the ***reeducation of both sexes*** on women's equal capacity for all branches of scientific and technological study.
- The presentation of successful minority women in any role modelling context should emphasise their ***normality*** in social, family and other roles as well as in occupational terms.
- Any strategy to use female role modelling to break the male stereotypes, should provide ***contrasting models*** (married, single, young, older experienced etc) and not be based on a dual role superwoman image alone.
- Breaking the stereotype by women's increased visibility is better achieved by improving female visible participation in contexts seen as ***normal management***, as normal decision making, and at ***mainstream*** ceremonial and public functions.
- Same-sex role modelling is effective as a process of breaking the stereotype through printed and pictorial literature, through educational materials and through careers and guidance literature. Federal and State educational authorities and Departments, educational institutions and educational publishers, should work to provide ***visible models of both sexes, in nontraditional roles*** as well as in traditional roles, ***in all educational materials***.
- Funds for policies to break stereotypes and to accredit nontraditional sex roles should centre on ***strategic mainstream*** use of key audio-visual and print media and not on project-based use of isolated minority women and men in person.

We have considerably more reservations about personal same-sex role modelling as a policy mechanism. We conclude that:

- There appears to be ***no valid research basis***, either grounded in rigorous theory or in sound empirical evidence, for concluding that the mere acquisition or increase of female staff in a given discipline or occupation would, in itself, result in an increase in female students or trainees in the discipline or occupation of the female role model.

- There appears to be no valid research basis for then concluding that female students or trainees would be inspired to make nontraditional choices ***merely and solely*** by seeing female role models in person in a particular discipline or occupation.

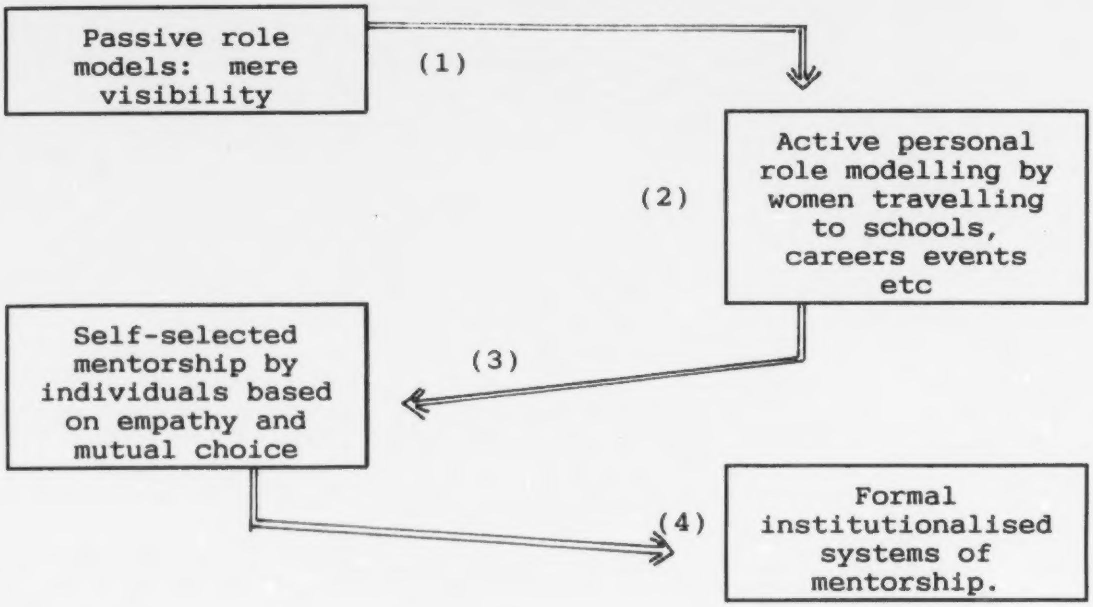
- The research basis for concluding that ***individual use*** of same-sex role models is more effective than cross-sex models in influencing curricular or career choice of students, is ambiguous, inconclusive and unproven, and is a poor basis for strategic policy-making.

- Same-sex female role modelling is accordingly not an appropriate policy mechanism where there is an expectation that already overworked minority women will carry it out in person in circumstances ***uneconomic in time, resources and energy.*** Women should not be pressured or expected to role model in person, unless they so wish. Projects should not be funded which centre on drafting minority women to role model in person, in the mistaken expectation that this would in any way increase female enrolments in nontraditional areas.

- Strategies in schools and colleges need to change from changing girls and women to ***altering male attitudes*** to females wishing to make nontraditional choices.

Role modelling and mentorship are part of a kind of continuum from passive to active. Thus:

Diagram 5.3


Passive role models: mere visibility
(1)
Active personal role modelling by women travelling to schools, careers events etc
(2)
Self-selected mentorship by individuals based on empathy and mutual choice
(3)
(4)
Formal institutionalised systems of mentorship.

We now turn to phases 3 and 4 of the continuum: different forms of mentorship which help both general career progression and advancement of untypical students (or staff) over barriers by active sponsorship and encouragement of senior colleagues.

REFERENCES

Aldrich, M. and Hall, P. et al (1980) Programmes in Science, Maths and Engineering for Women in the USA 1966-1978, AAAS and Office of Opportunities in Science, Washington, DC.

Almquist, E.M. and Angrist, S.S. (1971) "Role Model Influences on College Women's Career Aspirations" in Merrill-Palmer Quarterly, 17, pp.263-279.

Angrist, S.S. and Almquist, E.M. (1975) Careers and Contingencies: How College Women Juggle with Gender, Dunellen Publishing Co., N.Y.

Basow, S.A. and Howe, K.G. (1980) "Role Model Influence: Effects of Sex and Sex-role Attitude in College Students" in Psychology of Women Quarterly, 4, No.4, Summer 1980, pp.558-572.

Bell, A.P. (1970) "Role Modelship and Interaction in Adolescence and Young Adulthood" in **Developmental Psychology**, 2, No.1, pp.123-128.

Bell, A.P. (1970) "Role Models in Young Adulthood: their relations to occupational behaviours" in **Vocational Guidance Quarterly**, June 1970, pp.280-284.

Bowling, Jill and Martin, Brian (1985) "Science: A Masculine Disorder?" in **Science and Public Policy**, Vol.12, No.6, Dec 1985, pp.308-316.

Byrne, Eileen M. (1985) **Women in Engineering: A Comparative Overview**, Bureau of Labour Market Research, Monograph Series, AGPS, Canberra.

Clark, Yvonne, and Abron-Robinson, Lilia (1975) "Minority Women in Engineering Schools" in **IEEE Transactions on Education**, Vol.E-18, No.1,pp.34-35.

Daniels, J. and Lebold, K. (1982) "Women in Engineering: A dynamic approach" in Humphreys, Sheila (Edit) **Women and Minorities in Science: Strategies for Increasing Participation**, AAAS Selected Symposium, West View Press, Colorado.

Deblé, Isabelle (1980) **The School Education of Girls**, UNESCO, Paris.

Douvan, Elizabeth (1976) "The role of models in women's professional development" in **Psychology of Women Quarterly**, Fall, 1976, pp.5-19.

Dresselhaus, Mildred. S. (1975) "Some Personal Views on Engineering Education for Women" in **IEEE Transactions on Education**, Vol.E-18, No.1, Feb. 1975, pp.30-34.

Eggleston, J., Galton, M., and Jones, M. (1976) **Processes and Products of Science Teaching**, Schools Council Research Studies, Macmillan Education, London.

Erkut, Sumru, and Mokros, Janice (1984) "Professors as Models and Mentors for College Students" in **American Educational Research Journal**, Vol.21, No.2, pp.399-417.

Frohreich, Donna S. (1975) "How Colleges try to attract more women students" in **IEEE Transactions on Education**, Vol.E-18, No.1, Feb. 1975, pp.41-46.

Gelb, Lester (1973) "Masculinity and Femininity" in Jean Baker Miller (Edit) **Psychoanalysis and Women**, Penguin.

Gilbert, Lucia A. (1985) "Dimensions of same-gender Student-Faculty Role Model Relationships" in **Sex Roles**, Vol.12, Nos.1/2, 1985, pp.111-123.

Gilbert, Lucia, Gallessich, June, and Evans, Sherri (1983) "Sex of Faculty, Role Model and Students Self-Perceptions of Competency" in **Sex Roles**, Vol.9, No.5, pp.597-607.

Gilligan, Carol (1982) **In a Different Voice: Psychological Theory and Women's Development**, Harvard University Press, Cambridge, Mass.

Glaser, B.G. and Strauss, A.L. (1967) **The Discovery of Grounded Theory**, Aldine, Chicago, 1967.

Glaser, B. and Strauss, A. (1972) "Discovery of Substantive Theory: a basic strategy underlying qualitative research", Chapter 28 in Filstead, William (Edit)(1972) **Qualitative Methodology: Firsthand Involvement with the Social World**, Markham Publishing Co., (3rd Edition 1972), Chicago.

Goldstein, Elyse (1979) "Effect of Same-Sex and Cross-Sex Role Models on the Subsequent Academic Productivity of Scholars" in **American Psychologist** May 1979, Vol.34, No.5, pp.407-410.

Harding, J. (1983) **Switched Off: the Science Education of Girls**, Schools Council and Longman, London.

Kagan, J. (1964) "Acquisition and significance of sextyping and sexrole identity" in Hoffman, M.L. and L.W. **Review of Child Development Research**, Vol.1, Russell Sage Foundation, New York.

Kemper, T. (1968) "Reference groups, socialisation and achievement" in **American Sociological Review**, 33, 1968, pp.31-45.

Mischel, W. (1966) "A social learning view of sex differences in behaviour" in Maccoby, E.E. (Edit) **The Development of Sex Differences**, Stanford University Press, USA.

Mischel, W. (1970) "Sextyping and Socialisation" in Mussen, P. (Edit), **Carmichael's Manual of Child Psychology**, Vol.2, Wiley, N.Y.

O'Donnell, J.A. and Anderson, D.G. (1978) "Factors influencing choice of major and career of capable women" in **Vocational Guidance Quarterly**, 26, pp.215-221.

Oates, M.J. and Williamson, S. (1978) "Women's Colleges and Women Achievers" in **Signs**, 3, No.4, Summer 1978, pp.795-806.

Robinson, B.E. and Green, M. (1970) "On the nature of sex role transcendence" in **Australian Journal of Sex, Marriage and the Family**, 3, 1, pp.5-12.

Roeske, N.A. and Lake, K. (1977) "Role Models for Women Medical Students" in **Journal of Medical Education**, 52, No.6, pp.459-468.

Seater, B.B. and Ridgeway, C.L. (1976) "Role Models, significant others and the importance of male influence on college women" in **Sociological Symposium**, 15, Spring 1976, pp.49-64.

Shapley, D. (1975) "Obstacles to Women in Science" in **Impact of Science on Society**, 25(2), 115.

Spender, Dale (1980) **Man Made Language**, Routledge and Kegan Paul, London.

Sproule, B.A. and Mathis, H.F. (1976) "Recruiting and Keeping Women Engineering Students: an Agenda for Action", in **Engineering Education**, April, pp.745-748.

Stasz, Cathleen, Shavelson, Richard, and Stasz, Clarice (1985) "Teachers as Role Models: Are there gender differences in microcomputer based maths and science instruction?" in **Sex Roles**, Vol.13, Nos.3/4, 1985, pp.149-164.

Strauss, Mary Jo Boehm (1978) "Wanted: More Women in Science" in **The American Biology Teacher**, March 1978, pp.181-189.

Sutherland, Margaret (1985) **Women Who Teach in Universities**, European Institute of Education and Social Policy, through Trentham Books, (UK).

Tangri, S.S. (1972) "Determinants of Occupational Role Innovation Among College Women", in **Journal of Social Issues**, Vol.28, No.2, pp.177-199.

Tidball, M.E. and Kistia-Kowsky, V. (1976) "Baccalaureat Origins of American Scientists and Scholars", in **Science** 193, pp.646-652.

Welch, W.W. and Lawrenz, F. (1982) "Characteristics of Male and Female Science Teachers" in **Journal of Research in Science Teaching**, Vol.19, 7, pp.587-594.

Wheeler, J. et al (1979) **Case Studies and Promising Approaches: Vocational Education Equity Study**, Final Report, Vol.IV, American Institute for Research.

Young, C., McKenzie, D.L., and Sheriff, C.W. (1980) "In Search of Token Women in Academia" in **Psychology of Women Quarterly**, Vol.4(4), pp.508-525.

CHAPTER VI

THE MENTOR PROCESS: EMBEDDED, UNACKNOWLEDGED BUT CRITICALLY INFLUENTIAL

> ***"It is to you especially, august daughter of Melusine, that I am indebted for my proficiency in mathematics, to attain which I was encouraged by your love for this science, as well as your great knowledge of it, and by your mastery of all other sciences."***
>
> Dedication by Francois Viete
> of In Artem Analyticam Isagoge,
> to Catherine de Parthenay
> (Princess de Rohan)

It is rare to read of a distinguished *man* acknowledging his debt of mentorship to a *woman* of high intellect. And even rarer to read of it in published work, since women's contribution to science has been largely unacknowledged until the wave of published work on this in the 1970s and 1980s. But we know that ***mentorship*** has always been, and remains, one of the most important processes by which the gifted young are advanced in their scholarship, learning and careers.

Like most other influential issues in the politico-social area, mentorship has been discussed and studied principally as a male phenomenon in a male-as-norm paradigm until very recently. Over the centuries since Homer wrote of the original Mentor (tutor and adviser to Telemachus, son of Odysseus), it has been accepted as *normal* that patronage, preferment, the Old Boys network, have been male bastions. Yet as in other areas of equity and policy, the current political expectation that what is available to men in economic, political and social arenas must now be available to women, has still been seen as a *women's* issue, and not as a responsibility for mainstream management, or for institutional policy.

In our earlier discussion of institutional ecology, we identified mentorship as one factor present both at the level of the institution and in the ecological niche of Departments and disciplines. We were also, however, aware from our review of existing published works, of the likelihood of finding ambiguity in the strength of the belief in mentorship as a universal and essential panacea, but its highly variable base in rigorous research or monitoring. What we also found was that the serious study of the actual mentorship process was largely limited to business and commercial fields. Academe had not judged it a worthy research area.

While same-sex role modelling has been most extensively debated as an *access* question, mentorship has always been seen more as an influential factor in terms of *progression* and of advancement. Moving up the promotions ladder, or into influential policy areas, breaking into postgraduate research, these are all correlated with the active help of those ahead in the career ladder as well as with the ability and motivation of the trainee or student. We believe that mentorship is both a critical element of institutional ecology and a significant influence in women's ***retention and progression*** in nontraditional areas of study and employment. At the outset of the UQ WISTA research, we therefore built in a reexamination of this issue as one of the ten core factors. This was partly because a review of the published accounts of the biographies and work of women scientists had revealed very imperfect and imprecise evidence of the role model factor, but recurrent and quite unambiguous instances of direct mentorship of women by male scientists and mathematicians.

For when we look at the formative years of education and training, the published profiles, biographies and autobiographies of women seen as having successfully broken into nontraditional areas do contain a common theme of the presence of a mentor, a sponsor, an enabler, a senior or leadership figure who has been more than a role model. And while this has been sometimes written off as anecdotal, it is nonetheless real. The mentor emerges as rather an opener of doors, a sponsor to financial scholarships or award, a colleague who has created an arena for the protegée to show her gifts. The current received wisdom is that hypothetically, a mentor who is also female and a role model will be doubly influential in helping women. But sponsorship, grants, the award of jobs are reflections of the power structure. In science and technology in higher education, women are still fewer than 2 per cent of the top leadership. Mentors will, therefore, of necessity, more often still be male. Nor can we assume that women will, in fact, necessarily be supportive or even ready to take on mentorship when they are a very small minority at the top. High profile women are not always supportive to women behind them; and our role model analysis already highlights the danger of burnout and overload of minority women required to take on multiple extra roles.

Mentorship in Science

The role of mentors and sponsors is in particular well documented historically in the biographies of male and female scientists alike. T.H. Huxley, in addition to his many other roles, was a key figure in opening up science education to women in Victorian England. In Rossiter's (1982) account of women scientists in America from the early 19th century to the

1940s, the key factor in the accessing of science education for early pioneers was the specific sponsorship of sympathetic male scientists. Amos Eaton in particular not only helped early women scientists such as Emma Hart Willard and Mary Lyon, but trained them to train other women. Maria Mitchell, the astronomer and the first woman member of the American Academy of Arts and Sciences, owed her professorship at Vassar College to the specific keenness of Matthew Vassar to have a prominent woman scientist on his staff. She also became a key role model and promoter of science education for women (Rossiter, 1982). Again, it was Leo Konigsberger who thought so highly of Sofia Kovalevskaia's mathematical ability that he persuaded her (and helped her) to move to Berlin in order to work with Weierstrass, who also helped to overcome the discrimination at Gottingen University sufficiently to enable Kovalevskaia to be granted her degree *summa cum laude* in 1874, at a time when degrees were withheld from women. Weierstrass and Mittag-Leffler together continued to advise and encourage her, and finally it was the support and influence of Mittag-Leffler which obtained her a post in 1883 at Stockholm University (Koblitz 1983 and 1984). Kovalevskaia's achievement as a woman mathematician in a world hostile to the idea of intellect in a female head, was achieved only with the direct mentorship of contemporary powerful and supportive male mathematicians.

Florence Sabin's break-through research on blood, bone marrow and tuberculosis was, in her view, only possible because of the early help, advice and sponsorship of Dr Franklin Paine Mall of the John Hopkins Medical School in the late 1890s (Haber, 1979). Rosalyn Yalow, the second woman to win a Nobel Prize in Medicine and the sixth Nobel woman scientist, records both early mentorship and early prejudice. Her parents wanted her to be an elementary schoolteacher, but her physics professor at Hunter College (now City University) encouraged her to persist in University Physics. But when later as a teaching assistant at the University of Illinois and studying graduate Physics, she achieved A's in all sections except the laboratory element in which she achieved A minus, the Chairman of the Physics Department saw the three A's and one A minus which she had achieved and merely commented: "That A minus confirms that women do not do well at laboratory work" (Haber, 1979). Only active and constant mentor encouragement can help women to persist against such a negative stereotypic climate, which Friedl calls *"the universal cultural devaluation of women and their activities ... Why is the belief that women are inferior to men so prevalent a trait of human culture?"* Friedl, 1975, p.5).

But much as we discovered with role modelling, mentorship proved to be very variously defined and conceptualised.

WHAT IS MENTORSHIP? THE SNARK EFFECT

We first reviewed the most frequently cited research literature and analysed it for methodology and interpretation. Although mentorship in business and commerce has been relatively well discussed, the process in Academe has been so deeply embedded in Bordieu's *genesis amnesia* that digging out its presence and its characteristics, needs the persistence and intuition of porcine hunters of truffles in the Auvergne. And the mentor process, even when actually present in higher education, has, indeed, often been denied by those who practise it.

Analyses of the mentor literature as at the onset of our research in 1985 showed a general methodological fluffiness in the reported research undesirable for an issue so apparently influential. One early critic reviewed the role model, mentor and sponsor concepts as at the end of the 1970s, and found that the available studies were often methodologically flawed, the numbers too small or unrepresentative for generalisation, and the concepts ill-defined (Speizer, 1981, p.711). This poor or muddled definition at the onset of, or in the publication of, empirical research is a phenomenon shared with the role model issue. Speizer (Ibid, p.712) asks most pertinently "why, with so little research foundation, the concepts of role models, mentors and sponsors have caught the imagination of so many people".

Another review of research methodologies for assessing mentorship, described the then current received wisdom as a false consensus on the meaning of mentorship (Wrightsman [1981] p.3). This reviewer concluded that "it is only at a superficial level that 'everybody knows' what mentoring is", and particularly criticised woolly definitions proffered with no indications of their sources or justification.

Mentorship in business and commerce has been most simply defined as an active process of positive sponsorship by older patrons (teachers, managers, trainers, counsellors, senior women staff) towards younger or less experienced staff, students or trainees. In the business world, some of the key writers on mentorship in management, including Kanter (1977), have identified it as having and using the power to help someone by a form of patronage or individual personal sponsorship. It is particularly seen as using power to help someone to move upward by bypassing the usual hierarchical process, and it involves providing a generalised sponsorship which enables the person receiving it to achieve progress by a form of reflected power.

It is somewhat disturbing to discover how many of the influential researchers or policymakers in the mentorship area have continued to base their definitions, and hence their work, on that of Daniel Levinson (1978), despite the fact that his published study was based on a very small sample of male Americans aged from 35-45 years some two decades ago. As late as the mid 1970s, he was still using a male-as-norm paradigm. Levinson (1978) cites the influence of a mentor as critical in ensuring young men's (sic) professional (and, he says, emotional) development into adulthood and the middle years of professional influence. His much quoted definition follows:

> "A good mentor is an admixture of good father and good friend ..... A 'good enough' mentor is a transitional figure who invites and welcomes a young man into the adult world. He serves as guide, teacher and sponsor. He represents skill, knowledge, virtue, accomplishment - the superior qualities a young man hopes someday to acquire ... And yet, with all this superiority, he conveys the promise that in time, they will be peers. The protegé has the hope that soon he will be able to join or even surpass his mentor in the work they both value. A mentor can be of great practical help to a young man as he seeks to find his way and gain new skills. But a good mentor is helpful in a more basic, developmental sense. The relationship enables the recipient to identify with a person who exemplifies many of the qualities he seeks ... He acquires a sense of belonging to the generation of promising young men. He reaps the various benefits to be gained from a serious, mutual non-sexual loving relationship with a somewhat older man or woman." (Levinson, D., 1978)

We should note that despite Daniel Levinson's assertiveness of its value, he nevertheless concluded that most adults actually give and receive very little mentoring, and that this is the exception rather than the rule.

Roche (1979), also writing in the business world, defined a mentor quite decisively in terms of sponsorship. In his survey of 1,250 men and women business executives in America, they were asked "at any stage of your career, have you had a relationship with a person who took a personal interest in your career and who guided and sponsored you?" Women executives were only 1 per cent of the total, and tended to have several mentors (averaging three to the men's two). While the women executives had female mentors more often than men, seven in ten of the women's mentors were male. Only one in fifty of the men had a female mentor. In another American analysis located in the business world (Collins and Scott, 1978), mentorship was seen as ensuring that the careers of young people "get off to a good start". Out of these relationships, it was hoped that young people learn to take risks, accept a philosophical commitment to sharing and learn to relate to people in an intuitive empathetic way (Franklin Lunding in Collins and Scott, 1978, p.89). In interviews with three Chief Executives in the American Jewel Companies, three issues emerged which are generally explicit in business and almost wholly implicit in Academe. Firstly, the business world holds that executive responsibility involves assisting the people down the line to be successful (a role occasionally accepted but mostly rejected by the Deans and Heads of Schools attending our group interviews). Secondly, the concept is prevalent that mentorship involves actually going out and looking for people and telling them that they are good once their talent is spotted. We found this concept, however, to be embryonic at the articulated level in many academic UQ WISTA group interview discussions, and attitudes to deliberate mentorship were, at the least, ambivalent in our UQ WISTA institutions. Thirdly, mentorship in business involves deliberately creating opportunities for protegés to acquire new skills and to enable them to use them visibly to advantage (Collins and Scott, 1978).

Henderson (1985) looked at what he described as "formal mentorship programs" in American Federal, State and municipal government, and found the practice much less ideal than in theory. The mentorship programs were often resented by mentors (too much extra work) and recipients (jealousy from others) and non-recipients (felt excluded) alike. His respondents also showed a strong aversion in fact, to organised mentoring that imposed mentor:protegé relationships. He concluded that the roles of mentors and protegés are best formed under an organisational umbrella that actually promotes and expects mentoring but does not impose it (p.862) - or in UQ WISTA terms, as part of the positive institutional ecology.

Definitions of mentorship vary considerably according to the sector in which they have germinated: education, general business, top management, elite firms. Collins (1983) in a research-based review of professional women and their mentors, identifies five generic criteria for a true mentor: higher up on the organisational ladder; an authority in the field; really interested in the protegé's development; influential; and willing to invest more extra time and personal commitment than mere interest. Most recently, Hurley (1988) recorded a view, however, that researchers still could not agree on what mentors were, whether they are important to success, or whether and how formal mentor programmes could be effective. Yet the influence of Levinson, Roche and other 1970s researchers was seen by Hurley to have caused a widespread institutionalisation of mentoring. Formal mentor programmes were reported to be in place, for example, at nine major and high-profile American corporations. The concept has been further widened - and therefore considerably blurred - by extending it to teachers, parents, children, a stretching of definition and application which Hurley (p.42) records "most psychologists consider vague and unwarranted". Hurley comes down clearly against formal arrangements on the grounds that the reciprocity of mentor-protegé relationships involves mutual choosing, mutual respect and liking, and mutual give and take, which cannot be systematized without losing these very characteristics.

On the one hand, we recognised that how far previous published conclusions from the corporate business world can be soundly generalised to other career settings with different institutional ecologies, is debatable. Kram (1983) and

Queralt (1982), for example, both question the generalisation of received wisdom from evidence from one occupational sector to another, in the context of this issue. There is no doubt that there are some generic elements which appear to be common across sectors; others which are highly contextual to a particular sector. On the other hand, while mentoring under that label has not been widely researched in higher education, the process is well authenticated not only in published biographical work, but also in current reality.

When we came to look at the higher education sector as such, we noted that Levinson concluded a decade ago that "our system of higher education, though officially committed to fostering the intellectual and personal development of students, provides mentoring that is generally limited in quantity and poor in quality" (Levinson, 1978, p.334), a comment which was echoed by many of the Deans and Heads of Schools in our group interviews in the Australian survey institutions. But insofar as it exists, a number of different ways in which the mentor role works in education have emerged as well-established. At pre-University stage, science teachers in schools may take particular trouble to seek out access to scholarships for their gifted girls. In higher education it is, however, not only more complex but also more hidden, implicit, undefined. The system is seen to work in relation to such aspects as:

* recommendation for awards

* recommendation for postgraduate scholarships

* recommendation and appointment to part-time tutorships to enable concurrent postgraduate research to be undertaken.

* advice and encouragement to students to help them to progress over barriers.

* giving students more practical experiences in laboratory experiments with lecturers.

* enhancing a student's "visibility" (seminars, joint papers, conference attendance).

* discussing the latest scientific or technological work with students: brainstorming.

The last of these is particularly important and is what Martha White (1970) calls "*the biological library*", or our mentally stored inherited knowledge and understanding. White discusses in some detail the *informal* professional training processes which operated at the Radcliffe Institute whose women scholars she interviewed. White recognises that many professions and occupations have periods analogous to that of the medical internship or residency during which the individual learns to behave in ways which other people in the field regard as "professional". Such socialisation consists of learning the informal valued and attributed roles and the expectations which are an important part of real professional life. The process results in the gaining of a firmer image of self as a competent and adequate professional. This kind of learning is "caught not taught" and is a valued by-product of acceptance by and challenging association with other professionals.

And when the older professionals share their special knowledge and understanding outside the lecture halls to some, but not other, students, we are talking of mentorship. In science, in particular, the exclusion from informal channels of communication is important since knowledge is growing so rapidly. At any time only part of it is in the literature, yet women may have more limited access to the brains of the male fellow scientists who dominate the disciplines than their male peers. When women are hesitant to put themselves forward or to protest their exclusion, the pattern of exclusion is confirmed. White's analysis stresses what Egerton described as "biological storage" rather than mechanical or library storage; access to the knowledge in the brains of scientists and technologists which, it is held by both White and Bernard (1964), is more often shared in brainstorming discussions and informal interaction, between male lecturers and male students or male researchers, than between male lecturers and female students or female researchers. These take place over a beer, in pubs or clubs, and in Australia in "mateship" sessions from which women are often socially excluded (albeit more by cultural custom than by intent).

Another writer refers to the informal and invisible nature of the process. Cole (1981) in an American review of women's place in the scientific community, referred to "informal social networks ... detailed patterns of social interaction and sponsorship that are an essential part of successful careers" (p.390). He questions whether women have the same opportunities to establish what he calls apprentice relationships with older, eminent scientists. He describes these as "an important *mechanism* of transmitting a scientific tradition from one generation to another" (p.390). Cole's list of relevant *informal* processes in this context include informal scientific discourse with teachers, being asked to join the laboratories and research teams of senior professors, being asked to describe their work at conferences. Cole recognises that "there are no multiple regressions that can describe the impact of these social linkages", but comes down on the side of judging that women are relatively deprived in this regard. One can legitimately argue that the more informal, unidentified and embedded the process, the less likely that women will be freely admitted to what has been a culturally male process. In the words of a female lecturer who attended one of the UQ WISTA group interviews and wrote afterwards:

> *"... It will sound facetious but women cannot go out and play squash with the boss. Even male colleagues recognise a certain pattern of squash playing prior to promotions. For squash substitute various other social*

> *activities in which it would be unlikely for a chairman to be seen with a young female lecturer."* (University, Chemistry, letter 1986, 5/8)

Daloz (1986) in a wide-ranging study of effective teaching and mentoring, in higher education, describes mentors as guides who lead us along our journey, of notable importance at the beginning of our careers. Daloz confirms the embedded nature of the process: "unless there is some formalized process for assigning or recognising mentorships, the process remains largely invisible - a German instructor spends extra lab time with a particularly promising student, or a biology Professor and student begin to share problems of child care" (p.20).

Giles and Endsley (1988) have now attempted to define the generic. They have examined the mentor role in PhD programmes (25 males and 39 females) in Child and Family Development at an American State University, in the context of psychosocial relationships as well as of the mentor-protegé dyad. They developed a clearly defined model of Career Development Relationships (CDR) as the classical mentoring relationship, consisting of four generic elements: reciprocity in communication (frequency, variety, understanding), an affective bond (trust, respect, affection), the breadth and depth of influence, and the power differential. These researchers concluded that "high levels of professor influence and power and, to a lesser extent, high quality communication and strong affective bonds between professor and student all promote a positive graduate school experience both objectively ... and subjectively" (p.474).

This well-constructed research also clarifies not only that mentorship did clearly exist, and was influential, but *that students thought of their mentoring professors as more than teachers or sponsors.* The research also looked at peer relationships and concluded that student-peer communication is not related as such to career success in graduate school, but that peer emotional and social support did have some importance in the initial stage of graduate school. This may have implications for the peer element of the UQ WISTA ecology theory, and particularly for the time-lag factor.

In summary, the available evidence so far suggests that

- mentoring clearly does exist as a practice but is more clearly defined in executive business management than in the education sector;
- the concept and definition of a mentor varies across sectors and areas of influence and is still very imperfectly and ambiguously described;
- mentorship in the business world is generally selective and self-chosen, although increasingly is becoming

formalised; but mentorship in Academe is informal and rarely visible;

- there is as yet no clear, empirical research evidence to suggest the range and extent of the influence of mentorship, nor what proportion of young adults have access to this selective and self-selective process.

A further complication is that some published research commentaries on mentoring, see this process as highly sex-differentiated. Daloz (1986) criticised the male-as-norm basis of much of the published work, finding its value for women questionable. His analysis judged the research which suggests that "women define themselves in relation to others differently from men" as valid, and saw this as central to the mentorship issue. It is critical in higher education, because we simply do not have enough senior women staff in Universities and other higher education institutions to provide an equal pool of potential mentors with men, and therefore most mentoring of female students (if it takes place at all) will of necessity be *cross-sex* mentoring, whereas by definition for the same reason, most mentoring of male students will be *same-sex* mentoring.

MENTORING AND WOMEN

This brings us to whether the mentor issue is, in fact, different for women; and if, one accepted that mentoring is prevalent (even if imperfectly researched or recorded), whether it is also either sex-differentiated or sex-biassed. The same difficulty about lack of clarity and imperfect definitions applies to research on this aspect, but among a number of immediate questions arising from the review of available published research, we address the following:

- Is there any evidence that women are mentored more or less than or equally with men?

- Are women mentored differently from men?

- Given that mentorship started as a process by being male-to-male, that is same-sex relationships, are there factors which are now specific to a cross-sex mentor relationship?

We will review the first two questions in the light of available research and the UQ WISTA evidence, and return in the penultimate section to the problems of cross-sex (mainly male:female, as distinct from female:male) mentorship.

Certainly there is evidence that successful women have had mentors, including considerable biographical evidence. But the research evidence is uneven and inconclusive on the question of both access to and style of this process. Moore and Sangaria-Danowitz (1979, p.15) defined a mentor in the context of female University administrators as an individual who helps career advancement of others by "teaching the ropes", coaching, making important introductions; and 47 per cent of their sample identified a mentor by this rather general definition. Shockley and Staley (1980), however, left the definition of mentors to their female subjects, a rather unsound approach, and their sample was limited to thirty women who participated in campus-run seminars for women and management at the University of Colorado. Nevertheless, they did find that in answer to their over-generalised question "do you have a mentor in the organisation", 67 per cent replied that they had. One of the more thorough and substantial surveys is Riley and Wrench's (1985) study of mentoring of women lawyers (55 per cent of 2,300 members of a County Bar Association). Their definitions are clear and precise and follow well-trod paths and include conferring of status, providing essential information, active help and sharing of resources. Importantly, the researchers conclude that "the prevalence of mentoring found in this study is relatively low compared with the prevalence that has been reported in previous studies. One reason for this is the research design" (p.384). That is, the study distinguished between being "truly mentored" by a clear and strict definition of this (only 43 per cent of all women claiming mentors actually proved to be truly mentored), and receiving loosely-defined help. The researchers concluded that mentoring does remain important but depends on the quality of the mentor:protegé relationship itself.

In Henderson's (1985) study of American executives and managers from larger (over 100 employees) public organisations and government departments (N = 822), more than seven out of ten of his respondents of both sexes claimed to have had mentors. His definition was the over-general one used also by Roche (1979), that is someone with whom respondents had had a relationship at any stage in their career in which the person took a personal interest in the career of the respondent, helped to promote them or guided and sponsored them (p.858). Women executives in his sample had more mentors (average 2.72 to the male 2.44) and were three times more likely than a man to have a women as a mentor.

In Missirian's (1982) study of an admittedly select group of 100 top American women executive managers, she set out to explore wider issues. The study investigated whether Levinson's male-based mentor-protegé relationship was different for women; whether mentorship has stages and patterns of behaviour; whether mentors and protegés need to have shared values and goals; and whether sexuality is an issue to be addressed in the relationship. **She concluded that the answer was affirmative in each case.** She also concluded that her findings supported the general hypothesis that mentoring has, in fact, been a significant influence on the career development of successful female managers, and insofar as one relates this to top women who are the "rubric of exceptions" in terms of the Byrne scale of nontraditionality, her research findings are credible. One should note, before accepting her results as necessarily transferable, that the men and women in her sample reached the top by different routes: the men through clearly defined powerbased line management, the women more typically through the staff-personnel route which Missirian describes as involving only tenuous advisory power. If we look at the female professoriate in higher education, however, it may also be partly true that the reason why women professors are more highly represented in the Social Sciences and therapies is that more of us have entered Academe horizontally (coming in from an outside career) directly at the top (rather than crawling up the vertical academic structure), after a highly successful career in a less male-dominated profession and where mentoring is more overtly a part of career-structures: that is, also by a different route.

Vertz (1985) also looked at wider issues in the context of career advancement of seven groups of women in an American District Office of Internal Revenue. She analysed obstacles to be overcome if mentoring was to be successful. Her analysis of what reads as a thorough and well constructed study, identifies in particular the need for mentors to be aware of the often different career paths of women - for family reasons, or because they cannot relocate so easily or because they are one phase behind in the qualifications queue. (Having performed the qualification described in American as P.H.T [Putting Husband Through]). One should, however, note that many more professional women these days do not, in fact, have a very different career path from men; and particularly at graduate and professional levels. Sullerot's research almost two decades ago confirmed that in France, "the higher the woman's education, the less likely she is to interrupt her career" (Sullerot, 1973, p.85). Ten years later, a survey of women engineers in France showed that French women engineers have an initial economic activity rate of 85 per cent, four-fifths of working women engineers in young middle age were mothers and a quarter of women engineers put career before marriage until at least age 30, or double the national average (Ingénieur au Feminin, 1982). A similar profile is evident in Sweden; that is, some fifteen years ago, economic activity for women with higher education was 84 per cent compared with 65 per cent for those leaving after advanced secondary education. Within this, women engineers had an economic activity rate of 95 per cent (Women in Sweden, 1973). In USA, the work activity rate for women engineers and scientists in the late 1970s was already 89 per cent; and 85 per cent of women engineers expected to combine marriage, motherhood and employment as an engineer (Lebold et al, 1983). Thus, any model for improving the mentorship process by male academics, will need to take account of both the possibility that some women will have a different career path from men and that simultaneously, other women will increasingly have a career path indistinguishable from the male one. **To use one assumption to the exclusion of the other, is to return to sexrole stereotyping.**

It is not possible to conclude from these and other more minor studies, whether women are generally mentored equally with men. What does emerge is a generally reported high correlation between top women and past mentoring. But while Missirian (1982) found evidence of sex-differentiation in mentorship of women, other leading researchers did not, with the one exception of the sexual gossip issue which we deal with later. The balance of reported empirical evidence is that top women, when they do break through into mentorship, are more likely to receive a male-as-norm *range* of practical and psychological support. But they cannot receive the same *style* of mentorship, because theirs will almost always be a cross-sex relationship; and male students and junior staff, a same-sex relationship.

Nor is this solely an Australian problem. There is little sign of significantly changing trends on the international front. In UNESCO's recent (1987) study of the representation of women in higher education and research, for example, women averaged only from one-fifth to one-quarter of all students in the world's regions in the natural sciences. We clearly cannot therefore see a time in the years immediately ahead when the maximum proportion of women staff could in fact exceed this level. The female student enrolments in science vary from 18 per cent in 1984 in a sample of thirty one countries in Asia and 21 per cent in 1983 in a similar sample of African countries, to 24 per cent in 1984 in Europe (excluding USSR) and 23 per cent in 1984 in seven countries in Oceania (Australia's region). In the same survey, women as a percentage of all higher education teachers and researchers were 6 per cent in Japan, 10 per cent in Belgium, 15 per cent in Norway, 14 per cent in New Zealand, 22 per cent in Greece. When we subdivide to look at women in the natural sciences, the figures are even more variable.

TABLE 6(1)

WOMEN ACADEMICS IN HIGHER EDUCATION AS PERCENTAGE OF ALL STAFF IN ALL FIELDS AND IN THE NATURAL SCIENCES

COUNTRY	ALL FIELDS	NATURAL SCIENCES
	% WOMEN	% WOMEN
Canada (1983)	20.2	4.6
Belgium (1985)	23.5	18.4
Finland (1983)	21.3	12.7
France (1985)	23.7	23.2
Norway (1984)	15.7	9.9
Portugal (1985)	31.2	38.1
New Zealand (1985)	22.8	25.3

Source: UNESCO, Survey on the Representation of Women in Higher Education, Research, etc, Paris, 1987, Tables 4-7.

It therefore follows that not only in Australia, but in other countries, in the sciences in particular,

- most senior academic staff who are potential mentors will continue to be male;
- most female students, if they have a mentor, will therefore have a cross-sex mentor and a male:female relationship;
- most male students, if they have a mentor, will have a same-sex mentor, and a male:male relationship.

There are those who might question whether this matters, just as there were Heads of Schools and Deans and Professors who said during the UQ WISTA Group Interviews: *"But Professor Byrne, you are presupposing that it is a* ***problem*** *that women do not enter the hard sciences? So long as we have students, why does it matter who they are?"* So why does it matter who mentors whom?

Cross-sex Mentoring: Male to Female

Three issues which emerge as major factors, need review; that is, the expectation that any policies for helping women are a women's affair and not a male responsibility; the likelihood of gossip and jealousy from other colleagues and spouses; and the actual risk of sexual entanglement.

When we analysed both the responses to the UQ WISTA Discussion Papers and the issues and attitudes prevalent in the group interviews, we found that most of the written comments presupposed that women would work with young *women*. Relatively few suggested that women should work to break prejudice in male students, or that men should take on extra work *both* with young women (to encourage them) *and* with young men (to alter their negative attitudes to young women where these were visible). The perceived case for women working with women was typically expressed in one submission which came from the ground upwards, as it were, and which identified mentorship as giving an active message of willingness to help, as much as supported same-sex identification: *"I always found it very much easier as a student to approach a female teacher for assistance than a male one"* (Letter, Earth Sciences, University, female Technical Officer). This behaviour on the part of women students had been sufficiently widely reported and recognised as a phenomenon to gain reasonable acceptance on the part of our survey academics. But their conclusion from it, was to expect the women academics to concentrate therefore on helping women. In almost no interview or written submission, did male academics see this as a reason for looking at why it is that female students are put off by male behaviour, attitudes, discourse or other transmitted messages. Nor did male academics consider revising their teaching or supervision style or their transmitted attitudes to women as a result.

Male attitudes to women's professional advancement in higher education still remain ambivalent at best; overtly hostile at worst. Some males fear increased competition for scarce promotion or limited scholarships in recession. Others still genuinely, if anachronistically, believe that marriage and motherhood are incompatible with careers for women, but that marriage and fatherhood are irrelevant to careers for men. A recent survey of some 3,000 University staff has confirmed the continuation of these negative attitudes as late as the mid 1980s (Wilson and Byrne, 1987, Ch.4). In a male:male lecturer to student relationship, the need for a student's career advancement is an automatic given; in a male:female lecturer to student relationship, it is not. Where lecturers and Professors hold socially hostile views to employed or career-oriented wives and mothers, this acts as an implicit access filter in cross-sex mentorship.

Interestingly, this has been poorly recognised until recently, unlike the issue of sex in cross-sex mentoring. The issues of gossip and of potentially inappropriate sexual relationships are issues referred to in many of the more substantial research surveys.

One needs to distinguish the addition of an *affectionate* element born of close professional familiarity to a relationship, from the development of interaction into love or sexuality. In Levinson's (1978) research on which so much later work appears to have been based, he wrote of mentorship as involving "a serious, mutual *non-sexual* loving (sic) relationship with a somewhat older man or woman". He also assumed, however, that the relationship had the possibility of becoming sexual where opposite sexes were involved. But Daloz, writing nearly a decade later, uses images and examples in his detailed study of effective teaching and mentoring which merit the word affection rather than love as an ingredient in the relationship (Daloz, 1986). Other researchers have written of an "affective bond - the degree of respect, trust and/or love each feels towards the other" (Giles and Endsley, 1985).

Missirian's (1982) study attempts to distinguish true mentoring from sponsorship. Not everyone will agree with her that one element in true mentoring is what she describes as the intensity of emotional involvement, which she codes into three phases: respect, affection and love. Indeed, much of the evidence is to the reverse - that good, professional mentorship may well involve a friendly affection, but should carefully stop short of and *avoid* its development into something stronger. Indeed, in another contemporary major study of women and mentoring based on detailed and varied case histories (Collins, 1983), a successful professional woman was clear that "You have to be careful of appearances in male/female relationships. In my own case, I would have been reluctant to have so obviously attached myself to a male mentor, for fear it would have been misunderstood" (p.136).

There is greater unanimity on this latter issue - the problem of the perceptions of other colleagues, of the spouses of mentors, and of general, damaging gossip even where there is in fact, no actual impropriety in a relationship. One American survey of thirty female managers concluded that "a major risk for both mentor and protegé is the perception of others that a close association will evolve into sexual entanglement. This possibility is a concern of both". While most respondents to the survey did not consider that this was a major problem provided that the conduct of both was kept strictly professional, the researchers noted that sexual tension did exist in several of the relationships they reviewed (Fitt and Newton, 1981). Examining formal mentorship in American governmental public service, Henderson's (1985) study recorded a frequent problem that "sexual or intimate improprieties" were likely to be suspected by outsiders, when the mentor relationship was between different sexes (p.858). In Missirian's (1982) survey, there was credible evidence that mixed-sex pairs in the mentor relationship will be at risk of gossip, jealous spouses and sexual tension, **whether or not there is actual substance for gossip.** The issue can be summarised by this written response by a senior academic following one of the UQ WISTA interviews at which mentorship was discussed:

> *"The general exposure given to the topic of sexual harassment would make the role of male mentor to a female much more tricky, and the males would now prefer to stay clear of the whole thing. If nothing else, it is a convenient excuse to stay clear of any positive involvement with females. With any luck, discrimination is easier to defend and less embarrassing than sexual harassment charges."* (Letter, University, male Professor)

This brings us to the UQ WISTA evidence, and before reviewing the overall policy implications of our review of previous research evidence, we look further at the Australian evidence.

THE UQ WISTA EVIDENCE

Because the mentorship issue is not susceptible to statistical review in order to check hypotheses against grounded theory, in the way in which same-sex role modelling can to some extent be statistically monitored, one has to look for other more qualitative research evidence. We believe that the available evidence supports that mentorship does form some part of institutional ecology (visibly or invisibly, consciously or at the embedded level). We believe it is critically influential at the level of the discipline: that is, the ecological niche.

In the Discussion Paper on mentors circulated in 1986 to academic staff in scientific and technological disciplines in the UQ WISTA survey institutions, we defined mentor as "a sponsor, an enabler, a senior or leadership figure who has been more than a role model - rather an opener of doors, a sponsor to financial scholarships or awards, a colleague who has created an 'arena' for the protegée to show her gifts". We identified the evidence from research sources such as Rossiter (1982), Strauss (1978), Goldstein (1979) and White (1970) described earlier, and asked in the paper

(a) *Which of the mentor roles listed above do you see as more important or more influential in your discipline?*

(b) *Do you consider that the ways in which sponsorship or mentoring work in your institution either do, or may, disadvantage women students?*

(c) *Are you able to identify any observed differences in the way in which these operate for male and female students respectively in helping access to postgraduate work?*

(d) *Is there any way of moving from the current idiosyncratic approach to a more clearly criterion-based model? Is this desirable, or not?*

In sharp contrast to the almost universal immediate acceptance of the role model factor, many of those attending the group interviews in both 1985 and 1986 either did not recognise, or did not accept, the presence itself of mentorship as a process in higher education institutions, either as a self-chosen, self-selective activity, or as a formalised procedure. Those who attended our group interviews were much less ready to concede the strength of the mentor factor than the importance of role modelling. There was also a quite widespread belief that almost all lecturing staff were "objective", unbiassed, almost altruistic; and that even if mentorship existed, it was sexneutral.

Some respondents were unfamiliar with the concept as such:

> *"I was totally unaware of the (mentorship) concept until it began to appear in feminist newspaper articles a few years ago ... I have never been conscious of a mentor/mentee relationship in any (of my) work situations ... mentorship is much less common in engineering than it apparently is in business."* (Letter, Civil Engineering, University 5/7)

Even those who conceded its strength, appeared to have a form of *genesis amnesia* about its actual operation and influence. This comment was characteristic:

> *"Although there is evidence in the past of my subject (physics) that a mentor scheme, or patronage if you like, has been very strong, and I think that is true of chemistry, and possibly of mathematics, I think when you take the point of how does a student progress from undergraduate to postgraduate and then into the profession, in my subject it is done strictly by references and they are all confidential. I would be surprised if at that level, the mentorship weighed very much. Certainly, if you know the referee who is writing and you know it is your old friend X, then you would probably believe him a little more than your old enemy Y, but that's not the point. I would be very surprised, and I think this is where I share the view of my engineering colleagues, if this factor was as strong as, for instance, attitudes or prerequisites and mathematics."* (Interview, Physicist, University)

That is, the process is conceded for the past but denied as characteristic of current practices. In the same group interview, a geologist pursued the discussion and recognised the importance of mentorship in *progression* to doctoral studies:

> *"I think where a mentor is very important is in going on to a higher degree, say PhD level, and that this is where the influence can be the greatest in getting funding ... people tend to go into industry because our department has been an industry-oriented department. We have discussed this at length and we have been making an active effort to encourage more people to go on to PhDs and I think the encouragement by the adviser who is involved in an honours project is extremely important, at least in geology in our department ... It has been very important in our department."* (Interview, Geologist, University)

Others saw difficulties in finding good mentors in average staff either because of allegedly poor communication skills,

> *"On the subject of mentors, we mathematicians are particularly poor (inept?) at personal relations. I suspect that the abstraction and isolation of the subject attracts a certain aloof and incommunicative personality type. If so, finding compassionate mentors will always be difficult."* (Letter, Mathematician, University 1/11)

or because of perceived difficulty in obtaining industrial cooperation in placing female students in the necessary work-experience during University technology courses. In the case of mining, mentorship was seen as *external* to the Department, and not, in fact, part of its normal ecology.

> *"Mentors are difficult to find for male students ... much of the industry would look with some suspicion and a possible lack of acceptance at a male without industrial experience. You can imagine the problem for a female."* (Letter, Mining, University 1/9)

In analysing the interviews, we found that there was widespread agreement from Professors and Deans that active mentorship was not a role which the majority of their staff recognised or saw as their normal function. There was little difficulty in the academics in the group interviews accepting, however, a new concept of mentorship as a process beyond the criterion-based formal selection of students for progression (which they saw staff as readily accepting but which they universally saw as totally sexneutral). But the consensus was that this form of mentorship was not well done in higher education institutions towards either sex.

Some of the most vehement written responses, however, came from academics objecting to a description of current mentorship as idiosyncratic. In all of these cases, they defined mentorship solely in terms of formal structural arrangements for selecting students for higher degrees; a criterion-based process dependent on such factors as Grade Point Averages and references. These respondents saw references to idiosyncratic processes, as charges of discrimination, and in no instance did they refer to or appear to accept the existence of the unconscious or "sub-cultural" processes indentified in our Discussion Paper and in previous published accounts. This comment is characteristic of many:

> *"My belief as far as the Chemistry Department is concerned is that the teaching staff (all male) have shown no discrimination in encouraging undergraduates in their study and progress through the degree ... Over the years, female students at Honours and higher degree level have selected a wide range of staff members as supervisors."* (Letter, University Head of Department 3/13)

Certainly the latter point supports the fact that academics hold a firm belief that advice has Departmentally been evenhanded, rather than otherwise. Another academic commented that:

> *"I believe that all staff in this Department encourage all students to achieve to the level defined by their natural ability ... men and women students are treated in all ways similarly in lectures, tutorials and laboratories ... The proportion of women students in our courses has always been high and women are well represented in the lists of prizes awarded."* (Letter, Chemist, University 3/15)

This academic saw progression to a higher degree as "several years of very hard work in relative penury" and something of a lottery which women would be inclined to turn down because of marriage and family.

By contrast, among those accepting the existence of positive informal mentorship and supporting it, another wrote that

> *"I feel the offering of advice and encouragement is the most influential role that mentors fulfil within the Faculty at present. It indicates a caring attitude and can be carried out inconspicuously and privately. It can have a profound effect on self-esteem."* (Letter, Engineer, University 5/3)

The range of controversy whether mentorship is (or should be) solely a formal procedural process, or whether it is additionally (or alternatively) a subconscious process which has a subcultural aspect, showed a greater polarity than for role modelling. At one end of the spectrum, it was seen as potentially structural for undergraduates but not for postgraduates:

> *"The encouragement of appropriate students to take postgraduate study and to obtain scholarships is the limit of mentor activity at present. An internal proposal to provide a formal mentor structure for staff support of undergraduates is currently being considered ... (but) ... criteria inevitably limit flexibility. I would not support any formalism as applied to postgraduate selection."* (Letter, Computer Technology, Institute of Technology 10/6)

Yet it was precisely in relation to selection for higher degrees that most respondents argued for a criterion-based process and denied the existence of "flexible" or subconscious processes. Some academics of both sexes did, however, accept the reality of the existence of a mentorship subculture. One academic commented that:

> *"Mentors are most important in scientific academic life. Most crucial would be getting post-doctoral graduates into prestigious overseas laboratories and finding of part-time or temporary appointments while waiting for an opening. Concealed functions include a variable amount of help given in experimental planning and report writing in both honours and postgraduate degrees. I think visibility is less of a problem than it used to be since some societies favour the giving of papers by younger participants.* (Letter, Chemistry, University, female, 5/8)

The male Head of Medical Technology in another institution similarly writes of both socialisation and prejudice in the mentor role with an insight and honest accuracy not characteristic of the majority.

> *"The most important and influential mentor role is that which occurs during the ('internship or residency') apprenticeship time when the new graduate is being educated and trained to comply with the social values, sex roles and professional attitudes of the persons in the work place. The extent of this varies from place to place. Certainly, it can override any previous emphasis, taught or observed in the study course, in which the attitudes of equality are fostered. Naturally, it can be very difficult for the new graduate to overcome these 'built-in' prejudices which must be learnt and obeyed for success in that particular work place. These prejudices could also extend to the withholding of scientific and technical knowledge from any women in that workplace .... This question presupposes that the mentor role is to be a consideration in dealing with students at both the undergraduate and postgraduate level. I consider that academics need to be made aware of this research, so that examination of their particular conscious emphases may become apparent. No written or structured policy is necessary. Additional education of those currently in senior positions in laboratories needs to be aimed at showing how the 'apprenticeship' scheme affects the new graduate."* (Letter, Medical Technology, Institute of Technology, 10/10)

We do not suggest whether this description is widely true or rarely true; merely that it is part of the actuality of higher education practice, often hidden by *genesis amnesia*.

To summarise the main thrust of the subjective comment on and attitudes towards mentorship in the hundred or so group interviews with academic staff and in the written responses, we saw a much sharper polarity of view on this factor than on others. In the UQ WISTA survey institutions, we found that:

* **Some academics, including many Professors, Heads and Deans, rejected even the concept of mentorship as such, seeing the idea of any special help or encouragement to students as a negation of academic "objectivity" and an indirect accusation of favouritism or discrimination.**

* **Others saw mentorship solely in terms of the standard, procedural selection of students for progession to Honours, higher degrees etc; acknowledged its existence in formal terms, but rejected as outrageous any suggestion that this was in any way subjective.**

* **The possibility of particular encouragement or discouragement of individual students within a cohort first objectively selected on academic merit, actually to help them to decide to progress, was also rejected.**

Objectivity was seen by this group as universal in their Department and/or in their institution.

- **A small but significant number of academics, from male Professors to female tutors, accepted the existence of an uneven, necessarily subjective and informal system of mentorship in relation to progression to Honours and Postgraduate work, to industrial placement and to the informal but important sharing of scientific knowledge. This group saw the process as neither intentionally or overtly discriminatory, but as one of instinctive identification and empathy. They tended to believe that more open discussion of the concept and the processes would improve the mentorship process in their institution.**

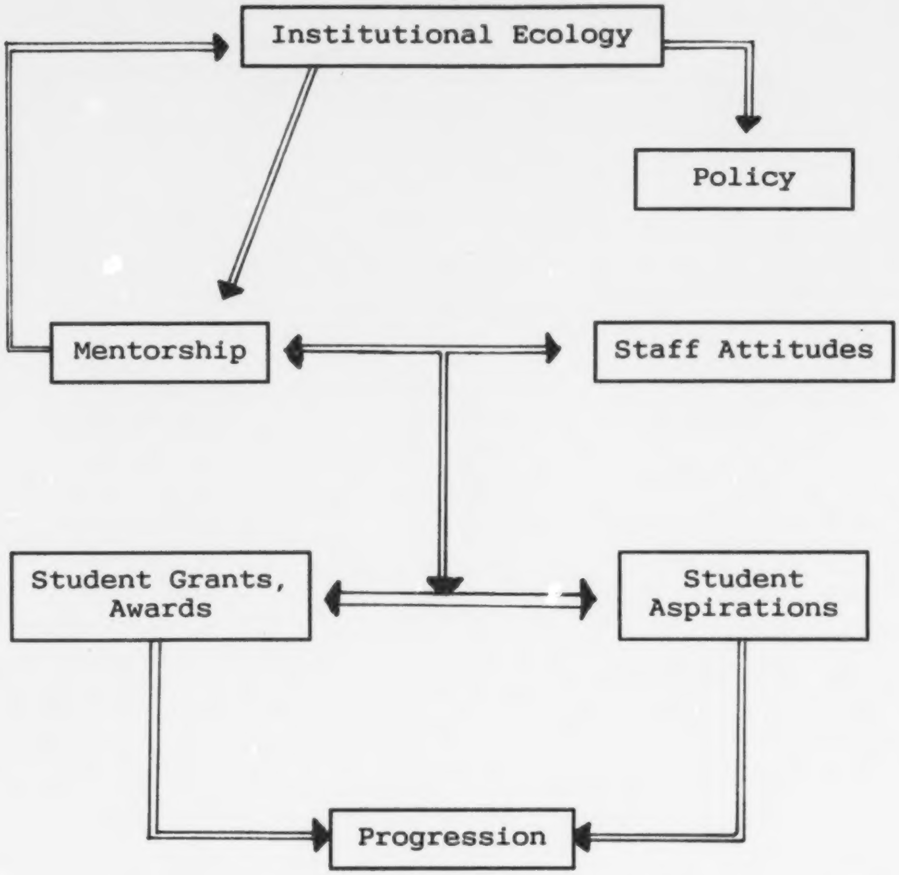
- **The possibility of unconscious sex-bias because of same-sex empathy or opposite-sex antipathy was generally, and complacently, rejected. Some academics still did not believe informal mentorship, where it existed, to be sex-biassed; others clearly did.**

- **There was marked conceptual confusion on the meaning and characteristics of mentorship within the academic groups attending the group interviews in each of the ten institutions. The extensive published debate about this process in the worlds of business and management and in the fields of training and supervision, does not appear to have reached the higher education sector in sufficient measure to make an impact. There was little evidence of any general institutional level of knowledge or awareness on the issue, before the UQ WISTA research team introduced the discussion on this.**

We argued in the last Chapter that role modelling was related to critical mass and image and was part of institutional ecology. Mentorship is, by definition, not related to critical mass or image. It does, however, form part of another ***cluster*** as illustrated in Diagram 6(1) on the next page.

One major question to be resolved is whether mentorship is to become more overtly recognised, more positively encouraged as a policy, and developed as ***cross-sex mentoring as a normal process***, rather than relying on same-sex mentoring, which provides *de facto* powerful mentoring for men, but limited service to female students.

Diagram 6(1)


Institutional Ecology
Policy
Mentorship
Staff Attitudes
Student Grants, Awards
Student Aspirations
Progression

REFERENCES

Bernard, J. (1964) **Academic Women**, Pennsylvania State University Press.

Blackburn, R. et al (1981) "Cloning in Academe: Mentorship and Academic Careers", in **Research and Higher Education**, 15, pp.315-327.

Cameron, S. (1978) "Women Faculty in Academia: Sponsorship, informal networks and scholarly success", in **Dissertation Abstracts International**, 39, 5971a.

Cercle des Femmes Ingénieurs (1982) **Ingénieur au Feminin**, Cahiers de CEFI, Paris.

Cole, Jonathon R. (1981) "Women in Science" in **American Scientist**, July/August 1981, pp.385-391.

Collins, Eliza G.C., and Scott, Patricia (1978) "Everyone who makes it has a mentor" in Harvard Business Review, Vol.56, No.4, July-August 1978, pp.89-101.

Collins, N. (1983) Professional Women and their Mentors, Prentice Hall, NJ.

Cook, M.F. (1979) "Is the mentor relationship primarily a male experience", in Personnel Administrator, 24(11), pp.82-86.

Daloz, Laurent A. (1986) Effective Teaching and Mentoring, Jossey Bass, San Francisco.

Erkut, Sumru and Mokros, Janice (1984) "Professors as Models and Mentors for College Students" in American Educational Research Journal, Vol.21, No.2, pp.399-417.

Fitt, L.W. and Newton, D.A. (1981) "When the mentor is a man and the protegé is a woman" in Harvard Business Review, 59, 2, pp.56-60.

Friedl, Ernestine (1975) Women and Men: An Anthropologists' View, Holt, Rinehart and Winston, NY.

Giles, H.W. and Endsley, R.C. (1988) "Early Career Development among Child and Family Development Professionals: the Role of Professor and Peer Relationships" in Family Relations, 1988, 37, pp.470-476.

Goldstein, Elyse (1979) "Effect of same-sex and cross-sex role models on the subsequent academic productivity of scholars" in American Psychology, Vol.34(5), pp.407-410.

Haber, Louis (1979) Women Pioneers of Science, Harcourt Brace Jovanovich, San Diego.

Henderson, D.W. (1985) "Enlightened Mentoring: a Characteristic of Public Management Professionalism" in Public Administration Review, Nov/Dec 1985, pp.857-863.

Hurley, Dan (1988) "The Mentor Mystique" in Psychology Today, pp.41-43.

International Labour Office (1980) Women's Participation in the Economic Activity of the World, ILO, Geneva.

Kanter, R.M. (1977) Men and Women of the Corporation, Basic Books, N.Y.

Klauss, R. (1981) "Formalized Mentor Relationships for Management and Executive Development Programs in the Federal Government" in Public Administration Review, 41, pp.489-496.

Koblitz, Ann Hibner (1984) "Sofia Kovalevskaia and the Mathematical Community", in The Mathematical Intelligencer, Vol.6, No.1, pp.20-29.

Koblitz, Ann Hibner (1983) A Convergence of Lives: Sofia Kovalevskaia, Birkhauser.

Kram, K. (1983) "Phases of the Mentor Relationship" in Academy of Management Journal, 26, pp.608-625.

Kram, K. and Isabella, L. (1985) "Mentoring Alternatives: the Role of Peer Relationships in Career Development" in Academy of Management Journal, 28, pp.110-132.

Lebold, William et al (1983) National Engineering Career Development Study, Purdue University, Indiana.

Levinson, Daniel (1978) The Seasons of a Man's Life, Alfred A. Knopf, NY.

Missirian, Agnes (1982) The Corporate Connection: Why Executive Women need Mentors to Reach the Top, Prentice-Hall, N.J.

Moore, K. (1982) "The role of Mentors in developing leaders for Academe", in Education Record, 63, pp.23-28.

Moore, K.M. and Sangaria-Danowitz (1979) "Mobility and Mentoring: Indicators from a study of women administrators", Paper to National Conference of AAHE (ERIC: EC 177975).

Reskin, B. (1979) "Academic Sponsorship and Scientists' Careers" in Sociology of Education, 52, pp.129-146.

Riley, S. and Wrench, D. (1985) "Mentoring among women lawyers" in Journal of Applied Social Psychology, 15, 4 pp.374-386.

Ritter, Frederic (1895) Francois Viete, Paris, cited in Alic, Margaret, Hypatia's Heritage, The Women's Press, London, p.135.

Roche, Gerard (1979) "Much ado about Mentors" in Harvard Business Review, Jan-Feb 1979, Vol.57, pp.14-28.

Rogers, Carl R. (1961) On Becoming a Person, Houghton Mifflin, Boston, Mass.

Rossiter, M.W. (1982) Women Scientists in America: Struggles and Strategies to 1940, John Hopkins University Press, Baltimore.

Shapiro, E.C., Haseltine, F.P., Rowe, M.P. (1978) "Moving Up: Role Models, Mentors and the Patron System" in Sloan Management Review, 19, No.3, pp.51-58.

Shockley, P. and Staley, C. (1980) "Women in Management Training Programs: What they think about Key Issues" in Public Personnel Management Journal, Vol.9(3), pp.214-224.

Speizer, Jeanne J. (1981) "Role Models, Mentors and Sponsors: the elusive concept", in Signs, Summer 1981, pp.692-712.

Strauss, Mary Jo B. (1978) "Wanted: More Women in Science" in The American Biology Teacher, March 1978, pp.181-189.

Sullerot, Evelyn (1973) Les Francaises au Travail, Hachette, Paris.

Vertz, Laura (1985) "Women, Occupational Advancement and Mentoring: an Analysis of one Public Organisation" in Public Administration Review, May/June 1985, pp.415-423.

White, M. (1970) "Psychological and Social Barriers to Women in Science", in Science, 1970, 170, pp.413-416.

Wilson, Brian, and Byrne, Eileen M. (1987) Women in the University: A Policy Report, University of Queensland Press.

Wright, C. and Wright, S. (1987) "The role of mentors in the career development of young professionals", in Family Relations, 36, pp.204-208.

Wrightsman, L.S. (1981) "Research Methodologies for Assessing Mentoring", Paper to APsA (ERIC: 209 339).

Yoder, Janice, Adams, J., Grove, S., and Priest, R. (1982) "Mentors: a debt due from present to future generations", Paper presented to the Annual Convention of the American Psychological Convention, Washington, DC, 23-27 August 1982.

CHAPTER VII

THE FORMATIVE YEARS: PRE-TERTIARY INFLUENCES: SINGLE-SEX, MATHS, IMAGE

> ***"I am not yet so lost in the lexicography as to forget that words are the daughters of earth and that things are the sons of heaven"***
>
> **(Dr Samuel Johnson,**
> **Preface to the Dictionary**
> **of the English Language)**

It is difficult to find a more sexist piece of thinking or writing than this eighteenth century reflection. Words are female, things are male; female words are of the earth, male things are of heaven. This polarity of mutual exclusivity has permeated the schooling system since its nineteenth century reconstruction. This Chapter looks at its twentieth century implications.

We have argued strongly that tertiary institutions cannot lay all of the accountability for women's unequal access to and progression in some major scientific and technological disciplines, on the schooling system. It is clear from the evidence so far that progression at least, and some aspects of access, are influenced by the ecological influences of Universities and Institutes.

Nevertheless, clearly the school years do have a major influence on curricular choice patterns, on the acquisition or not of relevant prerequisites (or prerequisite knowledge: not necessarily the same thing), on male and female attitudes to subject areas perceived as nontraditional for their sex, and so on. We review here, some of the major issues - and question again, some of the current received wisdom.

In Chapter III, we postulated that the institutional ecology of education consisted of a number of generic elements - discourse, role modelling and mentorship, image and structure and content of discipline. We now look at the cluster of factors at school level which create an institutional ecology (and within school physics, chemistry and maths, an ecological niche). For our "timelag" theory in Chapter III is based on an assessment that boys and girls respectively still live through a different, gender-based experience in the school years, and therefore come to higher education disciplines nontraditional for their sex, as into a different ecological niche. And we hypothesise that girls coming from girls' schools to a male-dominated science or technological subject, have a greater ecological mismatch and therefore need a longer timelag and support in their first year, than a boy from a boys' school or mixed school coming in to male-dominated higher education disciplines. This Chapter therefore looks at clusters of factors which are influential in upper secondary education and in the transition to higher education.

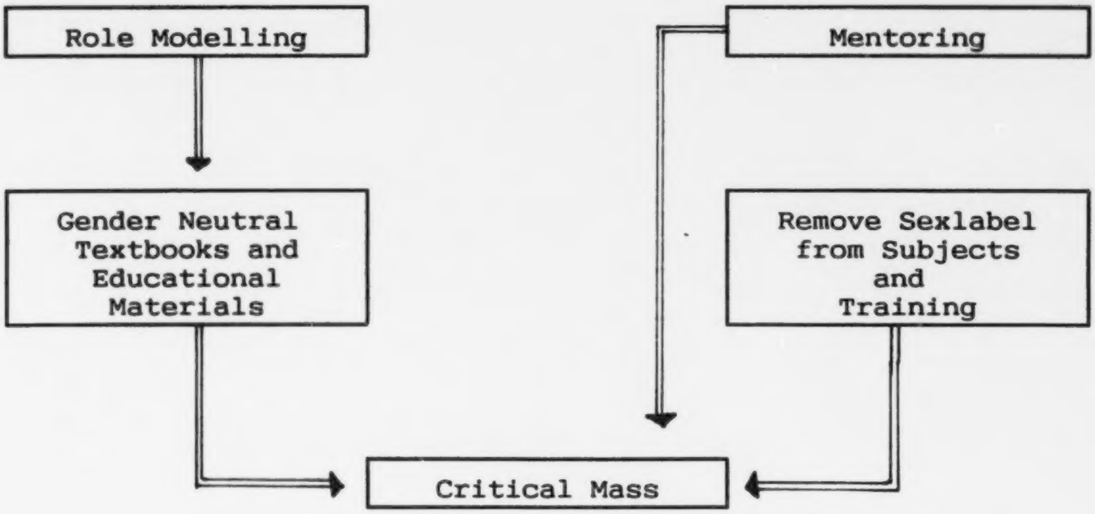
From a Dyadic Approach to Cluster-Factor Policy

Earlier in this Report, we criticised dyadic approaches to policy. Moving to a more holistic approach - dealing with a problem as a whole and not with one or two factors only - is important if policy initiatives are to give a good return-for-investment. Most of the 1970s' research which looked at girls and science has been dyadic - looking at the interaction of two factors only on each other (the effect of role modelling on careers guidance; the effect of vocational motivation on curricular choice). And some of this research does not even distinguish between *one-way* related factors on the one hand (*innate* intellect affects mathematical performance but improved mathematical achievement does not affect innate intellect), and *two-way* factors on the other (teacher expectation of girls in maths affects their motivation and achievement, positively or negatively, which further influences teacher expectation, which further affects girls' motivation and achievement). In turn, policy makers have tended to centre specific affirmative action policies on one or two factors only: the use of role models; or improved marketing at Careers Exhibitions.

If we wish to move towards achieving a *critical mass* of female enrolments in the economically-important scientific and technological disciplines and trades, in such a way as to normalise women's participation, we need to attack the problem through a cluster approach. Diagram 7(1) below illustrates one group of factors which need to be tackled together, if we are to achieve critical mass. That is to say, merely using more female role models will not work unless we also provide both gender neutral and interchangeable role models in educational books and texts. Similarly, we need actively to remove sexlabels from disciplines and subjects if they are to be seen as "role model normal".

Thus:-

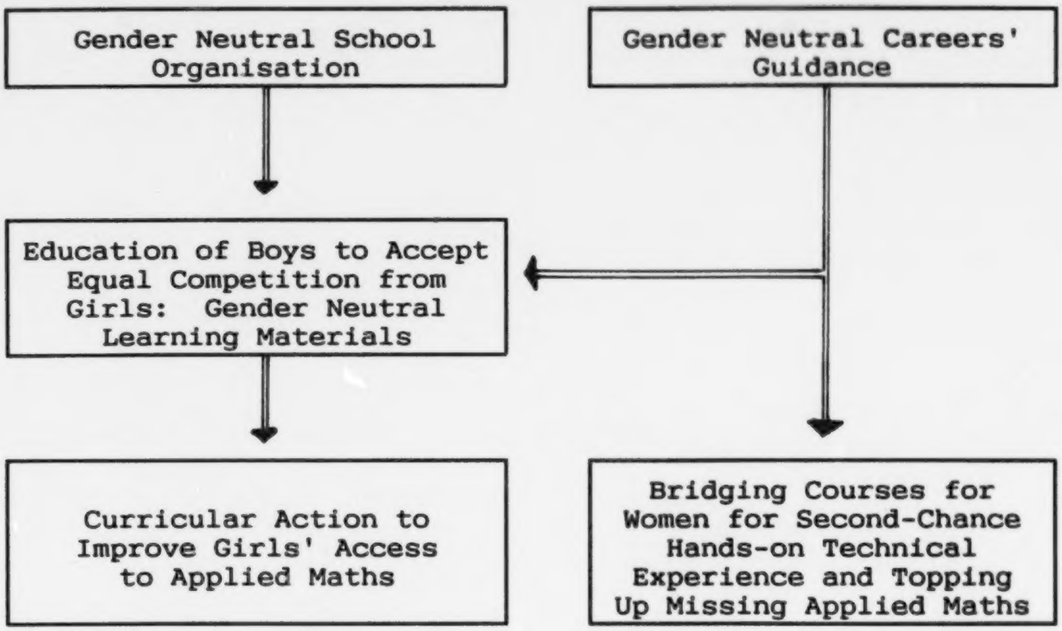
Diagram 7(1)


Role Modelling
Mentoring
Gender Neutral Textbooks and Educational Materials
Remove Sexlabel from Subjects and Training
Critical Mass

Thus, both girls and boys need to see school subjects and training areas as gender neutral, which is unlikely to be achieved until we stop transmitting sexist and stereotypic messages about the "maleness" of medicine, mining, management, maths, etc in education materials. Same-sex role modelling is most effective *through the print and visual media.* But at the same time, positive mentoring of able girls to help them to achieve equally in maths, science and technical crafts cannot be a same-sex process because we don't yet have a critical mass of women teachers in these areas. Male teachers in schools need, therefore, to take responsibility not only actively to help women students to see achievement as normal for their sex, but also actively to teach *boys* that women are equally capable and have an equal right to scarce places in science and technology.

There will, meanwhile, continue to be girls who come out of a gender-biased schooling with the "wrong" maths; without technical hands-on experience; or lacking adequate spatial development because they have been excluded from practical technical crafts. We therefore need policies from second-chance re-education and "topping-up" courses in applied maths, technical skills, to be available in order to help girls and women to reach the same levels of prerequisite knowledge: **bridging courses.** Diagram 7(2) illustrated below, suggests a group of related factors which, again, need to be tackled together.

Diagram 7(2)


Gender Neutral School Organisation
Gender Neutral Careers' Guidance
Education of Boys to Accept Equal Competition from Girls: Gender Neutral Learning Materials
Curricular Action to Improve Girls' Access to Applied Maths
Bridging Courses for Women for Second-Chance Hands-on Technical Experience and Topping Up Missing Applied Maths

In the event, the total grant and staffing resources for the UQ WISTA project, enabled us to look in depth at some, but not all, clusters of the factors listed on one axis of our theoretical framework. In this work and in planned monographs to follow, we deal with role modelling, mentorship, attitudes, image, mathematics as a critical filter and single-sex/coeducation. A follow-up three year grant (1991-1993) has been obtained from the Australian Research Council to look at the interaction of prerequisites, curricular choices and career education and career guidance, in the SHEP-APIST project (Secondary and Higher Education Policy: Access and Progression in Science and Technology).

One of the major controversies is whether the ecology of same-sex learning environments does, or does not, affect girls' progression in nontraditional sciences and in mathematics. Do single-sex schools help? And what is, in fact, seen to be the advantage?

SINGLE-SEX OR COEDUCATION? MIXED OR SAME-SEX CLASSES?

The current received wisdom on this issue is as entrenched as that on role modelling, and almost as suspect. Unlike role modelling, there is a mass of research evidence dealing with, or related to, single-sex and coeducational schools and classes. But much of this has been misinterpreted or considerably overstated, or its implications very imperfectly spelled out, often to the point of rank sophistry. We have also been struck at the near unanimity in the group interviews, with which otherwise sound and scholarly academics based their profound belief in the advantages of single-sex education for girls, on a totally unscholarly anecdote based on a sample of one ("my wife... "; "my daughter(s) ..."). Those who consulted their colleagues found the same:

> *"Many of the lecturers believe that girls in single-sex schools do better. However, when quizzed, it transpires that this belief is based on what you describe as the current 'received wisdom' rather than on serious examination of the question. None can quote studies..."* (Head of Maths, University, 1/3)

The debate about the relative advantages and disadvantages to girls and to boys respectively in the specific context of curricular choices and peer attitudes, of being educated in single-sex or mixed schools, dates only from the 1970s, from mainly British evidence. In the popularisation of the debate, assertions have become current which are not supported by much of the later, more scholarly and rigorous, research. The issue is considerably more complex than the current "received wisdom".

There are three main ranges of issues which have been raised. The first relates to girls' relative choices of and achievement in maths, science and technical subjects in relation to girls in mixed schools and to boys in both kinds of schools. The second relates to the role of single-sex (post-school) colleges in helping women's achievement and progression in higher education. The third deals with the environment of single-sex and coeducation in terms of girls' confidence, self esteem and vocational motivation, and with the apparently different ways in which teachers use language and discourse with girls and with boys respectively, in mixed and in single-sex environments.

In the subsequent educational debate, a number of assertions have moved to the status of strengthened hypotheses - some, but not all of which are significantly supported by subsequent research.

Hypothesis one	:	*more girls choose or succeed in maths, physics and chemistry in 16+ exams and at Advanced Level (Grade 12), in single-sex than in mixed schools.*
Hypothesis two	:	*more girls will go on to higher or advanced tertiary education in maths, science and technology from single-sex than from mixed schools.*
Hypothesis three	:	*girls are more likely to acquire confidence and higher self*

esteem in a girls' school than in a mixed school.

Hypothesis four : *more girls will choose nontraditional vocationally-oriented courses (engineering, mining, metallurgy, surveying) from single-sex schools or colleges; and fewer will drop out generally once enrolled from which ever type of school if in a single-sex college.*

Hypothesis five : *boys' domination of language and of teacher attention in the secondary years disadvantages girls in coeducational classrooms, discourages them to pursue "male" subjects like physics, maths and the technical crafts, and reinforces traditional sexrole course choices.*

There are a number of issues which have been raised in the decade since Her Majesty's Inspectorate (HMI) in England in 1975, published the first review of sex differences in mixed and single-sex schools since the Board of Education's 1923 report (DES, 1975; Board of Education, 1923). The HMI report suggested that in its survey of 10 per cent of all state maintained schools in England and Wales, "girls are more likely to choose a science and boys a language in a single-sex school than they are in a mixed school" (DES, 1975, p.12), but that for prevocational and practical courses, "girls in single-sex schools do not enjoy as wide a variety of these courses as do their contemporaries of either sex in any other types of school" (p.14).

The first general point which must be made, however, is that in England and Wales, in Australia, and in most European countries, the majority of single-sex schools are feepaying, academically selective, private or independent, and middle class; while most mixed schools are comprehensive (all ability), state maintained, and are weighted overall with proportionately more lower middle class and working class children. ***Straight comparisons are invalid*** unless that data has been specifically controlled or adjusted to allow for

(a) a generally higher ability intake in the majority of single-sex schools which are academically selective, and

(b) different social class intakes between the types of schools.

Wood & Ferguson (1974) checked out the data for 100,000 pupils entering for the Ordinary Level (Grade 10 equivalent) examinations in Britain. They looked at single-sex and mixed schools across 13 subjects and concluded that girls in girls' schools appeared to have a slight advantage in most subjects; that girls' only schools produced higher rates of female passes in physics and chemistry (than mixed schools); and that when schools change from single-sex grammar to mixed comprehensive, the success rate of girls reduced and that of boys improved. It is not, however, clear whether they controlled for relative differences of intake.

Ormerod (1975) applied the Brunel Subject Preference Grid to 1,204 pupils (518 boys and 686 girls) in ten single-sex grammar, five mixed grammar and four comprehensive schools drawn from four contrasting regions of England. Overall, he found that single-sex educated girls "have their preferences met by less satisfactory choices than do the boys ... the main weakness (however) is with coeducated girls" (p.265). His results on the Preference Grid led him to conclude also that *attitudes towards teachers* are likely to play an important mediating role in subject preferences, and should be included as a factor when interpreting sex differences between types of school.

Steedman (1983) questions some of the earlier conclusions about achievement in British single-sex and mixed schools. With a research grant from the Equal Opportunities Commission (UK), she reviewed the findings of the National Child Development Study (a longitudinal study of over 14,000 people born in one week in March 1958). The data were reexamined to check out single-sex and mixed secondary schooling and in summary, she found that "most differences between the examination results in mixed and in single sex schools are markedly reduced once differences in initial attainment and in home background have been allowed for". In relation to science, the NCDS reworked data, showed that while girls performed less well than boys in chemistry overall, there was *very little advantage* in girls' schools over mixed schools in girls' chemistry achievements. Similarly, despite a "very extreme" sex difference in physics enrolment and performance overall, girls' performance in relation to boys' was only *marginally* improved by being in a girls' school.

Steedman had been able to adjust the raw data for differential ability intake as between the types of schools, and (where appropriate) for social class. Sex differences in previously *unadjusted* scores showing slight advantages to single-sex schools in achievement of four or more "good" passes (per pupil), then diminished to minimal after adjustment. Mostly, where girls in girls' schools retained a performance advantage, this was in relation to high examination performance (the high fliers). She concluded that the small differences were "not enough to suggest that single-sex schools (or classes) would remove the sex differences in science performance (nor that mixed classes caused them)".

A review of the available evidence over the 1970s (Bone 1983), while including an overview of the examination success rate literature, raises wider issues. Bone's overall conclusion is that the research she reviewed found that the subject mixes taken by girls, their academic results and the "responses of schools to their more personal needs" have been more conditioned by the *type* of school (grammar selective, comprehensive all-ability, independent private) and its *style* (traditional or not), than by its single-sex or mixed status. However, girls do appear to be a little more likely to look favourably at "male" curricular areas when educated with other girls than in mixed environments in adolescence, although Bone's review suggests that girls' schools are still not "notably active" in encouraging departures from sex stereotypes. Also, girls of very high ability in academically oriented schools were less likely everywhere to be as sex stereotyped. On the whole, Bone concludes girls in girls' schools do not *generally* do better in maths and physics than girls in mixed schools, but girls in girls' *grammar* schools did better. That is, she concludes that the single-sex environment of itself does not have a significant effect on academic performance; only when single-sex schools are also grammar schools. Even then the advantage is statistically quite minor. At the more qualitative level, another issue is that while girls' *interests* were closer to those of boys when in single sex girls' schools, their *choices* were not necessarily so (Ibid, II 3.1 and 3.2).

Work at Chelsea College, London (now King's College) under Jan Harding's direction, has looked at entry and pass rates in both Nuffield and traditional externally examined science courses in the early 1970s. Her research project looked at sex differences, controlling both for single-sex and mixed schools and for type of school (grammar, comprehensive and independent). The results were interesting in that while the pattern of passes for *some* science subjects for *some* examining Boards showed an apparent advantage to girls in girls' schools, the sex differences in pass rates varied *within* a subject (eg chemistry) either with different Boards or with different types of school (eg grammar, direct grant, comprehensive), apart from sex of school (Harding 1979 and 1981). That is, there was not in fact a consistent difference between subjects (eg chemistry across all Boards as distinct from physics across all Boards), nor a constant finding when sex status of school was matched with type of school. Harding later questions whether it is not *teaching style* and organisational style of the school, rather than its single-sex or mixed status (Harding, 1983). Ormerod and Duckworth's review of a range of research dealing with attitudes to science concluded that boys and girls do appear to have generally different learning styles and to respond differently to various teaching strategies and teacher behaviours (Ormerod & Duckworth, 1975).

A second area of controversy in the single-sex/coeducation area is about the learning environment. Research into the area of gender and language (what language is used, how adults talk to boys and to girls, how much attention they give to each sex, etc) has suggested that (whether consciously or unconsciously), teachers of both sexes appear to treat boys and girls differently from each other in language, conversation and attention, and to treat girls differently when in mixed or in girls-only classrooms. Spender's work on gender and language leads her to conclude that females in single-sex groups are more likely to use a cooperative form of dialogue, males a competitive one and that when the two sexes are together, the male competitive mode wins. Spender cites research to support the view that women prefer a balance of talking and listening and are more reluctant to interrupt; and that girls in mixed classrooms are socialised into ceding to male dominance in answering teachers' questions. Girls hence do not acquire confidence in debate. Spender's work spells out convincingly the importance of language in "shaping our world" and in "classifying and ordering the world: our means of manipulating reality", (Spender, 1980). If her arguments have substance, the different performance of girls in teacher:student interaction in single-sex and mixed classrooms is potentially significant in maths and science lessons.

However, the experiments in single-sex classes in mixed schools have, perhaps predictably, produced mixed results. While some single-sex experiments have produced temporary gains in girls' confidence and participation, both staff and girls are more often reported as accepting the need to change the much-reported male domination, aggression or mockery in mixed classes to a teaching and learning process which gives equal opportunity for both sexes to develop (Kelly, 1981; Smith, 1980; Rhydderch, 1984). One survey reported girls as preferring single-sex classes (DES/HMI, 1980). But of the girls who were asked how much they had enjoyed their time at school in the Fifteen Thousand Hours survey of London schools in the 1970s, significantly more in mixed than in girls' schools recorded "quite a lot" or "very much" (Bone, 1983, p.111).

Similar questions must be placed over the research on classroom domination by boys as a factor discouraging on its own (for example) girls from pursuing maths or physics. That it forms part of a cluster of factors, may be less debatable. Among the major arguments put forward by protagonists of the *"single-sex schools advantage girls"* theory, are the apparent findings that in coeducation, boys dominate discourse; teachers give boys more time, attention, cueing and coaching; boys discourage girls from discussion by interruption and mockery; girls have lower self esteem, and so on. Doenau (1987) has reviewed several hundred studies of research on these and related issues in relation to coeducation vs. single-sex. His scholarly and rigorous reexamination of the "evidence" shows up the same suspect phenomena as the role model research reviewed earlier. He finds the following flaws in the most widely-cited research; for example:

* Many widely-cited studies are based, on closer examination, on infinitesimal samples (one teacher, ten lessons; one teacher, one lesson), which would make their basis for generalisation and their transferability, highly questionable.

* Some studies did not report the number of students involved at all; many did not report the location and type of school (rural, inner city etc).

* A majority of the studies did not define adequately what they meant by "praise", or "interaction" in teacher:student interaction; and observation was often methodologically unsystematic.

A fuller analysis of the weaknesses of research and policy conclusions in this area will appear in a separate monograph. The immediate implication of Doenau's review is that we can legitimately conclude that:

* No study shows females to have had **generally** more interactions with or help from teachers than male peers; a substantial body of research shows males to be favoured in interactions and in receipt of positive help; but a significant number of studies show no sex differences. *We cannot conclude that all coeducational settings are lethal to girls.*

* There is consistently strong evidence that males are cued, prompted or questioned more than females in coeducational classrooms.

* 29 studies show no sex differences in positive teacher:student interactions, 26 studies that males received more positive interactions, and 7 that females were favoured.

* More studies show that males receive both more praise and more criticism than females, but many studies show no sex differences. ***But the more soundly constructed and reported research shows that it is frequently a small minority of boys in a classroom who dominate, are disruptive and receive more attention; and not all (or most boys)***.

One implication of this is that it is less a question of sex-domination of environment than a question of discipline and of classroom management. Moreover, at tertiary level, the same applies. Lecturers need to assert control in lecture halls and tutorial sessions, over the excessive, crude, rude and harassing techniques of many male students who have minority women in their discipline, to ensure quite simply that the male pattern of discourse does not exclude the women students, mock them, treat them with verbal contempt and use louder decibels to communicate. It is the responsibility of lecturers to control the learning environment responsibly and to ensure a user-friendly ecological niche for both sexes in which to learn.

Some preliminary evidence from USA is frequently cited that attendance at single-sex colleges (postschooling) is seen as influential. How far it is the single-sex environment, however, and how far the maturer age of the women concerned and the nature of their early programmes in colleges, is hard to identify from the published records. For example, St. Mary's College, Indiana has developed a dual degree programme which enables women attending a single-sex liberal arts programme to pursue an engineering degree in addition to their two year degree in humanities (or sciences). It is believed that the women "have an opportunity to develop intellectually and socially without competing with men for leadership" and they are seen to enter the male-dominated third year with increased self assurance and confidence (Aldrich & Hall, 1980). Smith College and the University of Massachusetts have a similar dual-degree programme in liberal arts and engineering and for three years, students take a balance of both (second to fourth year) with a fifth year in engineering only (Ivey, 1982). In both cases, women's participation in engineering in the host University appears to have increased. It is arguably as much a question of greater maturity on entering the "male" programme, however, as the fact that they studied with women previously.

Nevertheless, assuming the perceived need for continuing protection from negative males to be the relevant factor, is this the right policy answer? The wave of projects setting up single-sex maths and science classes in schools since the late 1970s, clearly has been based on the assumption that it is. One of the most thorough experiments (funded by the UK's Equal Opportunities Commission) was single-sex setting in mathematics classes in Tameside, England, in the early 1980s (Smith, 1986). Despite some detailed evidence of positive gains by girls ("not made at the expense of the boys", p.40), the researcher concludes that "a school which mounts a sustained and coherent campaign to provide equal opportunities for girls in maths can succeed without using the particular device of single sex setting" (p.41) on the grounds that the gains were relatively negligible, and that the real factors of influence were the recruitment of three female maths teachers, *sustained efforts by all maths teachers* to ensure that girls play an active part in class, and attempts to change the male bias of the syllabus. All of these can and should be equally done in coeducation. Smith still, however, cautions against complacency - even after what was seen as successful action research, girls' performance in either setting fell short of parity with boys and more Grade 9 and 10 girls than boys still perceived maths as difficult. A later Australian study by Rowe (1988) of Year 7 and Year 8 students allocated to all boys', all girls' and mixed-sex classes set up in mathematics, tested the three groups of students across two school years. The most notable improvement was in girls' single-sex classes, and was associated with confidence levels. But again, this is a survey based on findings from a single school and is, by itself, not a basis for wider policy.

In summary, when we critically review the main cited studies, and when one takes these apart for such scholarly elements as size or viability of sample, control of variables, transferability of sample, validity of interpretation from data, a complex picture emerges. First, when single sex-coeducational studies are controlled for social class and ability, the sex differences between the sectors almost disappear. A larger majority of single-sex schools are private, socially selective or academically selective and feepaying, than state schools. *It is the nature of the school* and not its sex-base, that is the variable. Secondly, one cannot assume that same-sex role modelling "works better" in single-sex schools or colleges. In the first place, not all women are, in fact, desirable role models; some women teachers in fact, distil highly traditional sex-role views of the world. Nor can we assume that maths and science teachers (particularly Departmental Heads) in girls' schools are, in fact, women. A male scientist in a girls' school can often serve to reinforce the perceived masculinity of science. Nor do girls' schools even necessarily have a female Principal. Governing Bodies readily (and regrettably, increasingly) appoint male Principals in girls' schools (notably in Catholic and Anglican schools), where they would not dream of appointing a female Principal to a boys' school. The practice is increasing, not decreasing. Thirdly, much of the research evidence on single-sex schooling is unscholarly, or anecdotal, or based on small samples, or inconclusive.

Gill's (1987) review and annotated bibliography of Australian and overseas research on the overall single-sex/coeducation issue, also introduces a healthy note of critical scepticism. When one analyses the range of research which she also cites, it reinforces our view that there is no ***conclusive*** evidence on either side of the argument; and places strong question marks over the transferability of some of the most widely-cited research.

The Policy Case Against Single-Sex Education: Altering the Ecology, Not the Girls

While the evidence is contradictory, it should nevertheless be clearly established that there is no doubt that boys do, in fact, dominate over girls, demand and receive more attention and exert territorial priority over scientific and computing equipment, in at least some coeducational settings. While it is not universal, the evidence where it does occur, is convincing and serious in its effect and implications.

Where I differ from previous writers, is on the *policy* implications of this. It simply does not fit girls for either the ocker (uncouth, brash, crude) ecology of first year engineering or physics, or of the motor mechanics' yard, or of the apprenticeship workshop, to shelter them in the relatively more civilised environment of an all-female discourse and behaviour pattern for the whole of their years of schooling. There is considerable field evidence from Universities that the women who do manage to make it through to graduation when they are in what the Byrne Scale of Nontraditionality terms the "abnormal" or "rubric of exceptions" minority below critical mass, are either exceptionally gifted, unusually motivated and hardworking and, usually, very middle class (unlike many of their male peers). The girls who transfer over, in or after first year, to pure (as distinct from applied) maths or science degrees and out of engineering, surveying etc, are predominantly those who cannot - or will not - cope with the undiluted effects of impact from male students whose single-sex male schooling has reinforced their dominance, sheer decibels of voice, territoriality, assumption of automatic male priority, contempt for girls and sexual crudeness. (Those who doubt the prevalence of this pattern of male behaviour should work in a University Department of Teacher Education and spend a part of each year dealing with boys' schools, and with their male teachers.) These girls are, in our judgement, also those who need a "time-lag" adjustment to their new ecology in their first year and affirmative help in that adjustment. We argue that putting girls in single-sex classes or schools produces four negative outcomes, lethal to many mainstream unexceptional but nevertheless, bright or able girls when they move on from schools to higher education.

- It cushions them against the real world of training and work in which men remain the powerbrokers, and it does not teach them strategies for coping in the interim, until we succeed in changing a masculine learning environment to a gender-neutral user-friendly one.

- It perpetuates the masculine ecology unmodified, with the result that most male school leavers from the (parallel) boys' schools and classes remain contemptuous of females or underrate them and see no need to change: and they are likely until we reshape the workforce, still to predominate in workforce decision-making later (unmodified).

- It perpetuates the wrong paradigm of a female deficit model - that it is girls who must be sheltered and helped, instead of ***boys who need to alter***, and to learn to share equal discourse, not to interrupt excessively, to work collaboratively and not always competitively, to value human dimensions of science and technology and to treat women with intellectual and sexual respect.

- Most of all, it gives school, college and University teachers (of both sexes) an alibi for avoiding the real problem of classroom and lecture hall management and for avoiding the need to teach in a gender-neutral, student-centred and well-controlled learning environment.

For the problems of negative peer attitudes, of the poor image of some disciplines, and of presence or lack of esteem and confidence, stem from teachers and from the classroom environment: not unaided from students alone.

It is above all in the area of mathematics that the mechanism of single-sex classes has been raised. But the filter effect of mathematics is a much more complex matter for girls.

MATHEMATICS AS A CRITICAL FILTER

There are as many theories to explain the different patterns of achievement in mathematics, as between males and females, as there are researchers. We do not propose to re-canvass here, the range of theories and evidence, on which a separate, policy-oriented report will be produced. There are several main schools of thought. One attributes girls' lesser enrolment in advanced mathematics to *"maths anxiety"* on the part of the girls by the usual deficit model: some perceived flaw in girls' attitudes or in their capacity. Some researchers allege differential treatment of boys and girls in maths classes, by teachers, whether consciously or unconsciously. Others place high importance on the influence of prior experience (or the lack of it) with three-dimensional toys and educational materials, on the development of spatial ability: experience given more to boys than to girls, by both parents and teachers.

Early theorists even attempted to argue that the sex differences in maths performance (irrefutable) were due to universal (innate) female incapacity, despite Charlotte Perkins Gilman's (1902) trenchant declaration that *"there is no such thing as a female mind; as well talk of a female liver"*. And if one held this view of female incapacity, there would, of course, be no case for attempting remediation. Among significant studies which reject this genetic theory, the reports commissioned by the American National Institute of Education (NIE) to study maths avoidance in female students and to advise on policy changes, challenge the "female incapacity" theory (Fennema, 1977; Sherman and Fennema, 1977; Fox, 1977).

Others have written of "maths anxiety" (notably Tobias, 1978 and 1982) and in a more recent article, Tobias and Weissbrod (1980) review maths anxiety intervention programmes with some concern that "practice is moving ahead of theory and experimental research. Viewed negatively, this could produce careless and irresponsible 'maths cures'" (p.68). In either event, this blaming-the-victim approach still implies a policy of intervention programmes to remove the negative attitudes; unless we regard Frank Besag's latest work at Wisconsin as transferable and delete maths anxiety as a female cause, altogether. Besag and Wahl found no sex differences on maths anxiety or self esteem in a sample of some 7,500 students (Holden, 1987).

Others blame not the students, but school teacher attitudes and practices. That teachers do, in fact, (whether consciously or not) treat boys and girls differently in classroom interaction is well documented. In Becker's (1981) study of geometry teachers, teacher-initiated processes were weighted in favour of boys, who received more time and encouragement, attention and reinforcement. Brophy and Good's earlier (1970) study had confirmed that boys received more feedback and evaluative comment "both absolutely and relatively" and saw the teachers' different expectations of boys and girls as self-fulfilling prophecies.

The *image* of maths is cited by some, either in terms of its perceived usefulness vocationally (Armstrong & Price, 1982) or its perceived sex-appropriateness (Leder, 1976; Armstrong & Price, 1982). Yet others argue that the whole issue centres not on female incapacity or inferiority, but on a different female approach to spatial development.

Do girls still take less maths? Or different maths?

Fennema has argued throughout her extensive published work, a constant theme that girls' alleged "poorer" *performance* in maths, is principally because they do less maths than boys. Benbow & Stanley (1982) report on their late 1970s follow-up of the American Study of Mathematically Precocious Youth (SMPY) conducted from 1971 to 1974, with a final sample of 2,188 students as college "freshmen" of whom 57 per cent were male. They found, inter alia, that not only did SMPY males take significantly more semesters of high school maths than SMPY females, and in a significantly earlier grade than their female peers, but **that sex differences emerged in which elements of maths were taken at the upper levels.** The sex difference was apparently minimal up to trigonometry. "But then approximately 10 per cent more boys than girls took college algebra and analytic geometry ... with respect to calculus, approximately two thirds of SMPY boys took at least one calculus course, compared to 40 per cent of the girls ... We conclude that the gender difference in taking calculus in high school was important." (p.604). The researchers point out that "because SMPY girls took their maths later than SMPY boys, they had less time to do calculus and other advanced maths courses in high school (p.608). "Among the SMPY group, almost twice as many boys as girls took calculus in high school." (p.618).

In Fennema & Carpenter's (1981) review of the American National Assessment of Educational Progress (based on 70,000 9, 13 and 17 year-olds), they found that "only about two-thirds as many females as males reported they had taken either trigonometry or precalculus/calculus", although relatively few of either sex reported taking these courses (p.554). That is, there is a critical filter process within mathematics, as well as a filtering of girls out of access to Grade 12 maths. Why?

The UQ WISTA research team accordingly obtained from the Boards of Secondary School Studies (or equivalent) in each Australian State, (a) detailed statistics for secondary enrolments (not achievements) in Grade 12 subjects, including maths, for 1985, (b) a detailed breakdown of the content of the different mathematics courses in each State, and (c) the status of each maths course in the light of its content, for tertiary entrance. The data support that the filter effect is seen not only in overall female maths enrolments, but also in relation to precisely those units or courses which contain the calculus, matrices, geometric algebra work etc which the UQ WISTA Deans and Heads of Schools identified as missing in the preparation of more women students than men.

In Queensland, in the survey years of 1985 and 1986, girls were 43 per cent of Grade 12 Maths 1 candidates, but only 27 per cent of Maths II. It should be noted that Maths I includes two calculus units, probability and statistics. Maths II includes matrices, vectors, mechanics, and a third advanced calculus unit. Queensland ASAT records show Maths II students (both sexes) to be consistently more able than Maths I students. In New South Wales, the parallel figures were 54 per cent female enrolment in 2 unit maths, 40 per cent in 3 unit maths and 29 per cent in 4 unit maths. But 2 unit maths is designed as a general course and is only suitable for tertiary maths which is being taken as a minor discipline. For tertiary maths being taken as a major, 3-unit maths is required; especially for tertiary physics or engineering. 4 unit maths is of a higher level than 3 and tests for a "high degree of understanding of algebra and calculus".

In Victoria, the differentiation is less sharp. Girls were 53 per cent of general maths candidates, 33 per cent of Pure Maths A and 29 per cent of Applied Maths B. Maths A (pure) covers mensuration, probability, functions and calculus. Maths B (applied) covers functions, calculus, linear algebra, vectors, complex numbers, analytic geometry. In South Australia, interestingly, girls were 52 per cent of general maths, 33 per cent of Maths I and 33 per cent of Maths II. Maths IS (equals one maths subject only) is an alternative to Maths I and II and is not recommended as a pretertiary subject. Maths I and II are both seen as necessary for tertiary physics, engineering or tertiary maths. They work as a double major at Grade 12 and are complementary. Unlike the New South Wales 3 unit and 4 unit which are different in level and standard, the South Australian Maths I and II are complementary and of the same standard. In Western Australia, the pattern was similar to South Australia: female enrolment of 59 per cent in Maths IV, 52 per cent in Maths I and 32 per cent in Maths II and III. Maths IV is not designed for tertiary entrance. Maths I is meant to provide for general tertiary entrance and includes algebra, trigonometry and statistics but excludes calculus. It is less advanced than II and III. Maths II and III are a double major, are complementary and include algebra, trigonometry, analytical geometry, statistics and calculus.

(As part of the follow-up research project into curricular choice, prerequisites and career education [the SHEP-APIST Project], we have updated the figures for Grade 12 to 1990. The differential patterns are replicated for later years.)

The Australian secondary maths data supports the concern of Deans and Heads of Schools, and the findings of earlier research (including major studies not cited here for reasons of space), that ***the filter effect operates as much within mathematics in secondary education, as between maths and other subjects.***

While this filter effect continues, the answer is not to blame the schools with Pontius Pilate handwashing, but to provide tertiary-based remediation or topping-up programmes.

Special intervention programmes designed to top up missing maths, physics, technical skills in the USA, the UK, in Sweden and Denmark and in FR Germany, and which have targeted special groups at the post-schooling stage, have proved to have extremely effective and relatively swift returns for investment. In one American review of over 300 projects to increase the number and status of women in science, maths and engineering, a significant number were located in tertiary and higher education institutions - funded jointly by Federal aid and from the institutions' own funds (Aldrich & Hall, 1980). The (FR) German schemes which operate across all Länder and which have increased women's recruitment to scientific and technical training by very significant proportions, are also targeted at the late adolescent and young adult years and carry substantial Federal (systematic) funding.

It is not here argued that we should not, of course, work at longterm programmes of improved mathematics education in schools, but that this - if achievable - will not affect tertiary recruitment for many years and that we cannot wait to produce our missing tertiary mathematicians, physicists and engineers. Concurrently with a long term programme to attack the schooling issues, we need a mathematics remediation programme which will target, in particular, the female school leavers and young women who in the UQ WISTA data analyses are shown to have missed out on those particular elements of maths needed for physics, engineering and technological disciplines. This would also apply, of course, to any male school leavers who have equally suffered the critical filter effect through poor curricular or vocational guidance.

The UQ WISTA feedback

We therefore circulated a Discussion Paper on Maths as a Critical Filter to the Deans, Professors and Heads of (higher education) Schools who took part in the ten-institution survey. We recorded that in an earlier study of women and engineering (Byrne, 1985), Heads of Departments in tertiary institutions who responded to the enquiry, cited inadequate preparation in maths as one of the major critical filters which prevented girls from entering physics and engineering, or which caused their early dropout. Returns from Monash, Newcastle, Sydney Universities and the University of New South Wales, in particular, all spoke of either inadequate school preparation, or of the difficulty which women students experienced with first year physics and maths.

We therefore raised the filter effect of maths in the 1985 and 1986 rounds of group interviews with Deans, Professors and Heads of Schools in the ten UQ WISTA survey institutions as well as circulating a Discussion Paper. However, academic leaders of disciplines such as physics, engineering, mining, metallurgy, commented in almost all institutions that the problem was less that girls do not do maths, than that girls did a more limited maths or "the wrong maths" and noticeably were lacking in the kind of applied maths needed for physics, engineering and some technology. There was, however, considerable variation between staff in different institutions, in their estimate of the scale of this problem.

In the Discussion Paper academic staff were asked how they saw the role of higher education institutions in providing for bridging courses; for topping up courses; or for late entry to allow for study of missing elements in maths in a bridging year in the higher education institution. Some considered that prerequisites were too strict and that for some sciences in particular, there was an historic inheritance of expectation in advanced maths which the content of courses did not always justify. The filter process referred to above was seen by some as continuing at the tertiary level. This was characteristic of comments:

> *"Another barrier at the University level is the presence in many Universities of two strands of first year mathematics, an ordinary and a higher one. Typically, entry to the higher demands 4 unit maths for entry.* ***Girls (and others) who fail to meet this requirement are forever excluded from honours and higher degrees.*** (Maths Lecturer, University, 1/1)

We raised specific issues on whether higher education had a responsibility to deal with the perceived "inadequate maths" problem and if so, how?

Opinions were divided and academic staff adopted three main positions:

(a) Some (a significant minority) felt the problem was a schooling one; that it was not the task of Universities and Institutes to take on any remediation of lower level work; and that the policy issue involved was not one in which higher education had a role.

(b) Others (rather more) considered the matter urgent and critical if the problems of female under-recruitment to certain areas of science and technology were to be solved. They regarded the urgent systemic provision of bridging or topping up courses or of special maths remediation programmes as a priority policy issue. But they tended to see this as the task of tertiary colleges and did not wish to see higher education resources devoted to this.

(c) A third view was equally expressed. These staff adopted the main stance outlined under (b), but considered it essential that those programmes aimed at topping up the kind of work needed for higher education physics, engineering, applied maths etc, should be taught by higher education staffs in their own institutions. They either did not (rightly or wrongly) feel the confidence in the technical college system as a whole, to teach the "right" elements at the appropriate level. Or they considered the students would benefit from the more integrated approach of remediation programmes specifically designed as pre-physics, pre-engineering etc.

Within this group, representatives of several disciplines other than maths were confident that catching up was not impossible:

> *"The aim of maths remediation should not be primarily to provide missing elements but to improve attitudes and motivation towards the subject and to improve general mathematical manipulative skills through practice... The missing elements can readily be picked up as required along the way. Such remediation should be carried out within our institutions, and should be funded and credited. It would be a cost-effective investment."* (Head of Chemistry, Institute 2/1)

All who supported the higher education role in remediation or topping up or strengthening applied maths, were adamant that this was only possible with specific additional Federal funding for it.

The British Cockcroft Committee on mathematics teaching in schools, also saw it as essential that higher education institutions played a more major role in the inservice education of school teachers. The Committee, however, recognised that time spent on this was seen by academic staff as "to the detriment of their academic careers, because those responsible for making appointments do not value experience gained during inservice work as highly as evidence of published work. If this is the case, we regret it" (para. 742). The Committee recognised this as a sharper dilemma in relation to promotions but recommended an extension of consultancy work in inservice education not only because of its benefit to schools. It "also enables those who work in training institutions to gain up-to-date and first hand knowledge of the work that is going on in primary and secondary classrooms" (para. 743). Such a policy would also have implications for higher education staffing policy in general.

One of the reasons why mathematics is not taken equally by girls, is its image and the male peer attitudes towards this. Again, *dealing with maths alone without dealing with related factors, is ineffective.* Maths, image, positive mentorship and content of courses are all interrelated in two-way influential impact.

IMAGE AS A CRITICAL FILTER

Our extensive literature research review, produced a mass of evidence that *image* was a more important factor than had previously been recognised.

We also therefore circulated a Discussion Paper on The Image of Science to the Deans, Professors and Heads of Schools in our survey institutions. We identified in the Paper, three main aspects of image of disciplines which have emerged as critical:

- Ascribed **masculinity** or **femininity** of disciplines. Within this, boys subdivide their attitudes; some disciplines are seen by males as beyond girls' capacity (girls "can't" do maths or physics) and others carry a label of unsuitability (girls shouldn't do geology, surveying or engineering).
- Image of **social irresponsibility** or **social unresponsiveness** of disciplines. Disciplines seen as objective, detached, destructive, switch off girls and androgynous boys.
- Thirdly, different sciences and technologies carry labels of **difficulty** or **ease**, and of **vocational** usefulness (and therefore worth pursuing even if difficult), or of free-floating non-vocational interest.

Different researchers have related each of these aspects to sex-differentiated patterns of enrolment, retention and progression, and in practice it is not possible easily to separate them out because of their inter-reactions.

The male image of science

Many researchers have written of the perceived maleness of science; some of a patriarchal structure and bias in content, others of a male attribution. Arnold Pacey, for example, saw technology ("the application of scientific and other knowledge to practical tasks by ordered systems that involve people and organisations, living things and machines" [Pacey, 1983, p.61]) as not only value-loaded but as focussing on ranges of activities traditionally interesting to men but excluding the work of women, and saw a need to "challenge and counteract the male values built into technology" (p.107). Albury & Schwarz also saw science as reflecting "the prevailing world view of the male researchers of woman's inequality" (Broca's 19th century work on brain weights "proving" that womens' brains were lighter, now proves to be highly suspect, but prevailed for 50 years). They see the labelling of physics as a boys' subject as an "effective device for keeping girls confined to the humanities and the arts" (Albury & Schwartz, 1982, pp.87-90). Bowling & Martin (1985) see the masculinity of science as based on its dominant assumptions of competition and hierarchy as well as in the choice of (and exclusion of) topics for study. The scientific disciplines, they argue, are constructed as more process and system-oriented than flexible and shifting like human behaviour. But they do not define science precisely, and the argument is weakened when one contrasts different sciences whose construction differs between disciplines.

Others see the maleness of science as a transmitted media process which does not do justice to the actual social orientation and human variance of many aspects of scientific research. Rosslyn Ives also attributes the perceived maleness of science in Australia to the transmission of ideas about the world and conveyed to students by two media: science textbooks and science educators (who in turn learned from books and other educators). In an examination of secondary science textbooks in general science, biology, chemistry, physics, in 1984, males were represented in general science and chemistry books in a ratio (to females) of 5:1; in physics books by 8.6:1; and even in biology by 3:1. Authors also used predominantly male language (he, men, his, boys...) in examples in the texts (Ives, 1984). There are many other such studies from overseas research.

We are concerned less here, however, with the intrinsic masculinity (or otherwise) of different sciences, than with the ascription of maleness in different degrees to different disciplines. For example, Weinreich-Haste's studies with English school children found that both sexes rate physics, maths and chemistry as more masculine (4 and 5 on a 6-point scale) although boys rated all three as proportionately more male than did girls. Subjects rated as scientific were also perceived as "masculine, hard, complex, based on thinking rather than feeling". Girls saw science as difficult, "and they also saw complicated and difficult things as masculine" (Weinreich-Haste, 1981, p.221).

Ebbutt moves the issue nearer the classroom. His follow-up research examined the perceptions of both boys and girls as to whether there was "boys' science" and "girls' science" and if so, what they were. Both sexes, for example, saw elements like metals, batteries, circuits as for boys, and girls saw chemicals, crystals, tie dye as for girls (Ebbutt, 1981). While the origins of this male:female imaging may well lie in the prevailing social stereotypes, researchers argue that science teachers reinforce the image rather than counteract it.

In the British Girls in Science and Technology Project, the male "territoriality" of some disciplines rather than others, placed a stronger male label on physics than other school sciences; curriculum materials were seen to be heavily sex-biased, and boys held strongly sex stereotyped views against girls' active interest in aspects of science the boys saw as masculine (Whyte, 1986; Kelly, Smail & Whyte, 1983).

Peer attitudes are crucial in adolescence and in young adulthood. We also circulated therefore a Discussion Paper on Male and Female Attitudes as a Barrier, relating attitudes and image.

Our acquired attitudes are built up from our experiences and from the way in which we interpret these. They derive from "evidence" presented to us from which we construct what we see as "reality". Head (1984) describes an attitude in the context of science as an "underlying generalised construct". Certainly recent research in the areas of the psychology of sex differences, in vocational motivation and aspiration, and in achievement of adolescents, confirms this. That is, the influence of our attitudes and of other people's attitudes to us, does underlie most of our decision making. From this underlying influence, we generalise, to see certain behaviour or goals as "normal" for our sex, or our ability, or our social background. Adolescents are particularly unwilling to indulge in behaviour not seen as appropriate for their sex or for their age or within their peergroup. Hence the labelling of disciplines as sexnormal or gender neutral or sexabnormal, becomes a major barrier to "cross-sex" choices. Researchers have attributed up to 25 per cent of variance in science achievement to how students feel towards what they are studying, the learning environment and their self concept (Bloom, 1976). Earlier research attributed a further 25 per cent to the quality and type of instruction a student receives in terms of cues, reinforcement and encouragement to participate (Dollard and Miller, 1950).

Hostile male attitudes have been found by researchers at primary, secondary and tertiary levels. A Sydney study of 1,119 girls and 1,158 boys in the 1970s, looked at the attitudes of 9-13 year olds. Among the assertions drawn from the children's own sayings and then empirically tested, were that

* boys are better at maths and science than girls

* boys are cleverer than girls

* girls would not make good engineers

* boys make better leaders.

54 per cent of boys but only 5 per cent of girls thought boys were cleverer. Three quarters of the independent school boys and half of the state school boys thought that girls would not make engineers, were weak and silly, and 77 per cent of boys (but only 14 per cent of girls) thought boys make better leaders (Phillips, 1975). This clearly has implications for the learning environment of the ecological niche of classrooms and lecture halls.

Attitudes can operate adversely at tertiary level also. A Danish review of special efforts to increase women's enrolment to engineering, resulted in higher female dropout even after a significant initial increase. One reason given was that women students "are not taken seriously although they, to start with, have better marks (grades) than the male student on average. In spite of that they are often not regarded as sufficiently skilled technically to study at the place (technical university)." (Due-Billing and Bruvik-Hansen, 1983). The limited Australian evidence is conflicting on this, male academic staff recording an allegedly supportive attitude to women students, and women students reporting, as might be expected, no problems in some disciplines, to male mockery and harassment in others. In an American study, Clark and Abron-Robinson (1975) reported a variety of perceptions by peers and lecturing staff of female students' capacity in engineering, including hostility by male Professors to women undergraduates. Later American studies however, appeared to reflect some changes in the social climate since the mid-1970s, recording that minority women students tended to be more highly qualified and motivated, and therefore (implicitly) supported. Pressure from male peer students is still seen as more influential than adverse attitudes by male staff in Europe and in Australia.

A (male) University Lecturer in the UQ WISTA survey commented that:

> *"When I asked my student daughter to contact a woman lecturer at the Engineering Faculty of (X) Institute of Technology, she refused point blank because of the reaction of the male students during a previous visit. I would describe her as having more than average self confidence and ability to respond to such behaviour. I*

> *think only a minority of students actually live up to the coarse, beerswilling image, but it may be a significant factor in discouraging women."* (Engineering Lecturer, University, 5/7)

It would be possible, of course, to write off widespread reporting of adverse male attitudes as subjective and anecdotal, despite a growing body of serious research; or to see it as only a problem in schooling. Reports from students in tertiary institutions however, from counselling staffs, and from lecturing staff concerned about female underachievement or "channelling" into limited options, suggest that there is significant replication at the tertiary level of an early ingrained male hostility to females competing in areas seen as territorially male. Males are also widely reported in research and in Australian studies of the status of women in tertiary institutions, as having more traditional attitudes to women's longterm role outside the home, than females.

The social image of science

There is a growing literature on the extent to which the way in which children and school students may see science as a social process and its role in society, may influence their decisions to pursue or to reject and drop (a) science in general and (b) certain disciplines of science in particular. By the mid-70s, a wide range of research had discussed the influence of students' attitudes to science (Ormerod and Duckworth, 1975) and in particular, sex differences in attitudes. And within the latter, the social implications of science have come to emerge as more influential than was considered a decade ago.

Ormerod tested the Brunel Attitude Scale to science in 1969-70 on 261 boys and 264 girls drawn from a wider sample taken from 17 British schools matched for type of school and for single-sex-coeducational. The attitude scale distinguished subject preference, and social attitudes to science and the perceived social responsibility of science. He concluded that his data showed a strong significance between high social scores (ie seeing science as socially responsible) and later choice of science in the case of girls, but, in his sample, a low correlation in the case of boys. *This "social factor" had emerged strongly by the third year of secondary education,* which Ormerod rightly considered had implications for curriculum design (Ormerod, 1971). The research, though useful in accrediting the issue as an issue, had some weaknesses. Ormerod only used the term "science" in this early research, not distinguishing between physics, chemistry and biology. The Brunel Science Attitude Scale uses "science" simultaneously to describe a school subject ("science is the most boring subject on the timetable", not distinguishing physics from biology) and simultaneously a whole area of life ("with the aid of science, I look forward to a brighter future", "science is destroying the beauties of nature").

Later research subdivided the scientific disciplines more thoroughly. By the mid and late 1970s, Ormerod had worked with a number of researchers to test out different angles of the attitudinal question. Ormerod developed the Brunel Subject Preference Grid (Ormerod, 1975) which he tested in both mixed and single sex schools on 1,200 pupils of 14+ in the top 25 per cent of the ability range. He found not only that the social implications factor was much less evident with biology than with physics and chemistry, but that those with favourable attitudes to the social implications of science (ie regarding science as socially useful, relevant, helpful, exciting etc) were significantly more likely to choose physics and chemistry at 14+ than those with unfavourable or indifferent attitudes (Ormerod, Bottomley et al, 1979). Work by Bottomley and Ormerod using the Brunel SOCATT grid also found that the social implications factor would also override even dislike of teachers for girls, but the reverse was true for boys. That is, girls with a favourable attitude to the social aspects of science would still choose science even if they scored highly on dislike of the teacher. The research did not, unfortunately, distinguish the sex of the teacher, and it is difficult to relate this therefore to the same-sex role model issue) (Ormerod, 1979).

Further study of the social image of science, leads back to sex-differentiated perceptions of different elements of science. (For example, boys are more often reported as seeing lasers as useful in war and defence, or negatively; girls more often in relation to the curative and therapeutic use of lasers, or positively.)

A Danish study takes this issue of elements of science further in the context of a major longitudinal study of physics teaching in Danish upper secondary schools. Among other issues, the researchers investigated students' attitudes towards syllabus topics in physics. One central question was "what would you like to learn more about in physics?" While the sex differences are not as great as previous research would lead one to expect, boys are overall more interested in everyday technology and in rockets and space technology than girls; girls more interested in natural phenomena (wind and solar energy, lightning and thunder) than boys (Nielsen & Thomsen, 1985). This and other research into the elements of different sciences, suggest a correlation between perceived traditionally male/female activities and levels of interest - which poses a dilemma for the construction of new curricula. For interest is, in turn, seen by other researchers as highly correlated with a discipline's perceived social responsibility.

Interest is also reinforced (or otherwise) by the media and by textbooks. Pratt (1981) in a review of American elementary school science books, found that four of those most frequently used, in 1977, did not cover social problems at all. National Science Foundations materials had only slight social coverage. In a major world review of sexism and sexrole stereotyping in school texts and children's books, UNESCO found that even in countries like Norway with a long established anti-sexist and anti-stereotypic policy in education,

> *"Discrimination against girls in Norwegian textbooks is particularly noticeable in science textbook illustrations... pictures of girls/women are used when electric hairdryers and bathroom scales are to be shown..."* (Michel, 1986, p.27)

In the French study in the UNESCO world survey, it was found in physics texts, references almost exclusively oriented to interests known to attract boys: electric trains, male sports, factories, industry, astronomy. Even books in the natural sciences were found to have a "marked mechanistic dehumanisation". In middle school science texts "boys solve all problems and are good at do-it-yourself while girls are (shown as) incompetent" (Ibid, p.28). The media replicate this, but also tend to portray scientists and engineers with negative images. Albury & Schwartz saw the coverage of science and technology in the national media in Britain as remarkably consistent - "the work of scientists and technologists is a vaguely sinister, mysterious activity that ordinary people cannot understand" (p.107).

American research does not wholly support the British data, however, on attitudes of school students. An American study of the decline in science achievement in 9, 13 and 17 year-olds since 1979 led to the National Assessment of Science in 1981-82. The study looked at the image of science defined as "impressions or perceptions which are held by members of a group and are symbolic of basic attitudes and orientations", or in Jungian terms, "deposits of accumulated experience". The main focus was to identify the current images of science in the USA and to check for variations by sex, race and geographic location (Hueftle, Rakow & Welch, 1983). Fewer than half of the 9 year-olds in 1982 recognised that people write stories better than computers. More school students responded positively in 1982 than in 1979 on "persistent societal problems" (pollution, world hunger etc) but there was no overall statistically significant sex difference between males and females. And while boys consistently reported more positive attitudes towards science in general, than girls, the differences were again only of the order of 3 per cent. Boys showed a "statistically significant decline of 3.0 per cent of socio-scientific responsibility items" (p.25); but girls were 13 per cent less certain than boys that they could have an impact on the problem of running out of resources.

In response to the UQ WISTA Image Discussion Paper, the "social" image of maths was seen by respondents as possibly more detrimental, by girls, than its masculine attribution by boys. Characteristic of this angle is the following comment from one leading University mathematician who saw maths as having a major image problem: male, lacking a social responsibility image and anachronistic.

> *"As to its social responsibility image, almost all applications of maths offered in both schools and Universities are 'male' (eg the speed of projectiles and the like). Yet precisely the same maths that underlies these (the calculus) is equally applicable in more curative and therapeutic applications that might appeal more to girls. For example, in the modelling of the spread of epidemics, or population growth of interacting species, or the dissipation time of drugs in the body. Something could be done immediately here."* (University Lecturer in Maths [Male], 1/1)

Engineering, physics and chemistry emerged as the disciplines most seen as having an image problem.

> *"Chemistry has a major image problem. It is related to its social responsibility, which is perceived to be more important by girls than boys. Chemistry compared with biology is seen to be difficult, unimportant and uninteresting, though less so than physics. At this stage, still 'male' on a three point scale."* (Head of Chemistry, Institute, 2/1)

> *"Yes, physics has an image problem. No doubt the connection between physics and nuclear bombs and war technology has some effect... The image has male attribution since males are naturally more aggressive and in general do not mind the war technology image... The media (reinforces), in some way it is the* ***correct*** *image. Physics has enormous potential for good or evil and we would be foolish to ignore that the evil part creates many jobs for physicists... Physics has to play the earlier role of classics. Without some physics knowledge and understanding, a person in the modern world is uneducated... (physics) will have a dramatic effect on our standard of living ten or fifty years hence. Physics with its precise use of language disciplines the mind. This is the positive image."* (University Professor and Head of Physics, 3/2)

> *"Yes, mechanical engineering has a major image problem... It is confused with mechanical* ***trades*** *which are seen as often involving dirty work in unpleasant circumstances and conditions... The image is most strongly transmitted through the media."* (Institute, Principle Lecturer, [Male], 4/1)

A female Lecturer from a different Institute echoed this.

> *"There is a problem in building a clear and positive image of engineering; the term* ***engineer*** *is used to describe positions ranging from domestic engineer to sound engineer, from locomotive engineer to professional engineer... from unskilled labour to high level research... the male domination is not perceived in a*

positive way by the general public. It seems to have acquired all the negative elements of football, motor racing and Big Brother." (Female Engineering Lecturer, Institute, 2/2)

In the feedback both in interviews and in responses to the Discussion Papers, engineers most of all tended to see their disciplines as having a major problem of public and educational image - that is, both students and teachers underestimating the social responsibility and human orientation of different forms of engineering, and overestimating its "oily-machine oriented anachronistic image". Despite the contrary evidence from research into schooling, few physicists, however, saw problems of image in their discipline. Geologists reported variously on conflicting images - attractive to women if presented as a tidy science, negative to women if presented as a rough outback discipline. In the written replies, image emerged however, on the whole as an underestimated and oversimplified issue, except for engineering.

In terms of remediation policies, our survey participants were much more inclined to blame the written and electronic media, and schools or parents, for their unfavourable image. The idea of altering content, bias, focus and marketing in higher education as part of its ecological environment, occurred to only the occasional isolated physicist, chemist or mining engineer.

It is clear that to remedy the impact of the clusters of factors reported in this Chapter, requires a new policy approach. We turn to this in our final Chapter.

REFERENCES

Albury, David, and Schwartz, Joseph (1982) Partial Progress: The Politics of Science and Technology, Pluto Press, London.

Aldrich, M., and Hall, P. (1980) Programs in Science, Maths & Engineering for Women in the United States: 1966-1978, American Association for the Advancement of Science.

Armstrong, Jane, and Price, Richard (1982) "Correlates and Predictors of Women's Mathematics Participation" in Journal for Research in Mathematics Education, 1982, 13, (2), pp.99-109.

Becker, Joanne Rossi (1981) "Differential Treatment of Females and Males in Maths Classes" in Journal for Research in Maths Education, Vol.12, No.1, pp.40-53.

Benbow, C.P., and Stanley, J.C. (1982[a]) "Consequences in High School and College of Sex Differences in Mathematical Reasoning Ability: A Longitudinal Perspective: in American Educational Research Journal, Winter, 1982, Vol.19, No.4, pp.598-622.

Bloom, B. (1976) Human Character and School Learning, McGraw Hill, NY.

Board of Education (1923) Differentiation Between the Sexes in Secondary Schools, London.

Bone, Ann (1983) Girls and Girls-only Schools: A Review of the Evidence, Equal Opportunities Commission, Manchester.

Bowling, Jill, and Martin, Brian (1985) "Science: A Masculine Disorder" in Science and Public Policy, Dec. 1985, pp.308-316.

Brophy, Jere, and Good, Thomas (1970) "Teachers' Communication of Differential Expectations for Children's Classroom Performance" in Journal of Educational Psychology, 1970, Vol.61, No.5, pp.365-374.

Byrne, Eileen M. (1985) Women and Engineering: A Comparative Overview, Bureau of Labour Market Research, Canberra, pp.59-61.

Clark Y., and Abron-Robinson L.A. (1975) "Minority Women in Engineering Schools" in EIII Transactions on Education, February (1) pp.34-35.

Committee of Inquiry into Teaching of Mathematics (The Cockcroft Committee) (1982) Mathematics Counts, HMSO, London.

Cowell, Barbara (1981) "Mixed and Single Sex Grouping in Secondary Schools" in Oxford Review of Education, Vol.7, No.2.

Department of Education and Science (1975) Curricular Differences for Boys and Girls, Education Survey 21, HMSO, London.

DES/HMI (1980) Girls and Science Report of HM Inspectorate, HMSO, London.

Doenau, S. (1987) Are Teachers Fair to Girls? Advance Publication, Pennant HIlls, NSW.

Dollard, J. and Miller, N. (1950) Personality and Psychotherapy, McGraw Hill, NY.

Due-Billing, Y. and Bruvik-Hansen, A. "Research: Women's Attitudes to Technological Studies, Especially Engineering" in Contributions to Second GASAT Conference, Oslo, 1983.

Ebbutt, Dave (1981) "Girls' Science, Boys' Science Revisited" in Kelly A. (Edit) The Missing Half, Manchester University Press, pp.205-215.

Fennema, E. (1977) "Influences of Selected Cognitive, Affective and Education Variables on Sex-Related Differences in Mathematics Learning and Studying" in Shoemaker, J.S. (Edit) Women and Mathematics: Research Perspectives for Change, National Institute of Education (NIE), Washington.

Fennema, E. (1978) "Sex-related differences in maths achievement: Where & why?" in Jacobs, J. (Edit) Perspectives on Women & Mathematics, Columbus, Ohio.

Fennema E., and Carpenter T. (1981) "Sex-related differences in maths: Results from National Assessment" in Mathematics Teacher, Oct. 1981, pp.554-559.

Fennema E., and Sherman J.A. (1977) "Sex-related differences in maths achievement, spatial visualisation and affective factors" in American Educational Research Journal, 14(1) pp.51-72.

Fennema, E., and Sherman J.A. (1978) "Sex-related differences in maths achievement and related factors: a further study" in Journal for Research in Maths Education, Vol(9) (3), pp.189-203.

Fox, L.H. (1977) "The Effects of Sex Role Socialisation on Maths Participation and Achievement", in Shoemaker, op.cit.

Gill, Judith (1987) Which Way to School?, Commonwealth Schools Commission, Canberra.

Harding, Jan (1981) "Sex Differences in Science Examinations" in Kelly, A. (Edit) The Missing Half, Manchester University Press.

Harding, J. (1979) "Sex Differences in Examination Performance at 16+" in Physics Education, Vol.14, July 1979.

Harding J. (1983) Switched Off: The Science Education of Girls, Longman, for Schools Council, London.

Head, John (1984) The Personal Response to Science, Cambridge University Press, Cambridge.

Holden, Constance, reporting in Science (8.5.87), p.660.

Hueftle, S., Rakow, S. and Welch, W. (1983) Images of Science, Science Assessment Unit, University of Minnesota.

Ives, Rosslyn (1984) "The Maleness of Science" in Australian Science Teachers Journal, Vol.30(1), pp.15-20.

Ivey, E. (1982) "Engineering at Smith College" in Engineering Education, December 1982.

Kelly, A. (1981) (Edit) The Missing Half, Manchester University Press.

Kelly, A., Smail, B., and Whyte, J. (1983) Initial GIST Survey: Results and Implications, Manchester Polytechnic.

Leder, Gilah (1976) "Contextual Setting and Mathematical Performance" in The Australian Mathematics Teacher, 1976, pp.119-127.

Mahoney, Pat (1985) Schools for the Boys? Coeducation Reassessed, Hutchinson, London.

Mead, M. and Metraux, R. (1957) "Image of the Scientist Among High School Students" in Science, 126, pp.384-389.

Michel, Andrée (1986) Down with Stereotypes! Eliminating Sexism from Children's Literature and School Textbooks, UNESCO, Paris.

Nielsen, H. and Thomsen, P.V. (1985) "Physics in Upper Secondary Schools in Denmark" in European Journal of Science Education, Vol.7, No.1, pp.95-106.

Ormerod, M. (1971) "The Social Implications Factor in Attitudes to Science" in British Journal of Educational Psychology, Vol.41, No.3, pp.335-338.

Ormerod, M. (1979) "Pupils' Attitudes to the Social Implications of Science" in European Journal of Science Education, 1, 2, pp.177-190.

Ormerod, Milton B. (1975) "Subject Preference and Choice in Coeducational and Single Sex Secondary Schools" in British Journal of Educational Psychology, 45, pp.257-267.

Ormerod, Milton B. (1981) "Factors Differentially Affecting the Science Subject Preferences, Choices, and Attitudes of Girls and Boys" in Kelly, A. (Edit) The Missing Half: Girls and Science Education, Manchester University Press.

Ormerod, M., and Duckworth, D. (1975) Pupils' Attitude to Science: A Review of Research, NFER-Nelson, Slough.

Ormerod, M., Bottomley, J. et al (1979) "Girls and Physics Education" in Physics Education, Vol.14, pp.271-277.

Pacey, Arnold (1983) The Culture of Technology, Basil Blackwell, Oxford.

Phillips, Shelley (1975) Young Australians, Harper & Row, Sydney, 1975.

Pratt, H. (1981) "Science Education in the Elementary School" in Harms, N.C. and Yager, R.E. (Eds) What Research Says to the Science Teacher, Vol.3, National Science Teachers' Association, Washington, DC.

Rhydderch, Gill (1984) Half the Class: Strategies for Single Sex Teaching Groups in Mixed Schools, Unpublished paper to Girl Friendly Schooling Conference, Manchester Polytechnic, 1984.

Rowe, K. (1988) "Single-sex and Mixed-sex Classes: The Effects of Class Type on Student Achievement, Confidence and Participation in Mathematics" in Australian Journal of Education, Vol.32, No.2, pp.180-202.

Sarah, E., Marion Scott, Spender, Dale (1980) "The Education of Feminists: The Case for Single Sex Schools" in Spender D. (Edit) Learning to Lose: Sexism and Education, Women's Press, London.

Smith, S. (1980) "Should They be Kept Apart" Times Educational Supplement, 18.7.80.

Smith, Stuart (1986) Separate Tables? An Investigation into Single-sex Setting in Mathematics, EOC Research Series, HMSO, London.

Sherman J., and Fennema E. (1977) "The study of mathematics by high school girls and boys: Related variables" in American Educational Research Journal, 1977, (14), pp.159-168.

Spender, D. (1980) Man Made Language, Routledge & Kegan Paul.

Steedman, Jane (1983) Examination Results in Mixed and Single Sex Schools: Findings from the National Child Development Study, Equal Opportunities Commission, Manchester.

Tobias, Sheila (1978) Overcoming Math Anxiety, W.W. Norton, New York.

Tobias, Sheila (1982) "Sexist Equations" in Psychology Today, Vol.16, January 1982, pp.14-18.

Tobias, Sheila, and Weissbrod, C. (1980) "Anxiety and Mathematics: An Update" in **Harvard Educational Review**, 50, (1) pp.63-70.

Wienreich-Haste, Helen E. (1979) "What Sex is Science?" in Harnett, O., Boden, G. and Fuller, M. (Eds) **Sex Role Stereotyping**, Tavistock, London.

Weinreich-Haste, Helen E. (1981) "The Image of Science" in Kelly A. (Edit) **The Missing Half**, Manchester University Press, pp.216-229.

Winchel, R. Fenner, D. and Shaver, P. (1974) "Impact of Coeducation on 'Fear and Success' Imagery Expressed by Male and Female High School Students" in **Journal of Educational Psychology**, (1974) Vol.66, No.5, pp.726-730.

Wood & Ferguson (1974) "The Improved Case for Coeducation" in **Times Educational Supplement**, (4.10.1974) p.22.

Whyte, Judith (1986) **Girls into Science & Technology**, Routledge & Kegan Paul, London.

CHAPTER VIII

CONCLUSION: POLICIES FOR CHANGE?

> *"The great tragedy of science: the slaying of a beautiful hypothesis by an ugly fact."*
>
> **T.H. Huxley**
> **Collected Essays: Biogenesis and Abiogenesis, 1894**

Application of detailed scholarly review to current received wisdom, results in the slaying of a good many faulty hypotheses which have become embedded in the attitudes and assumptions of the men who still dominate and administer higher education. (Australia has just achieved only its second female Vice Chancellor in a century of higher education.) Scholarship now establishes without possible doubt, that women have equal intellectual capacity with men in any area of study or work (out with biological determinism); that women also do, in fact, wish to participate in all arenas hitherto labelled as territorially "masculine", and that some have been doing so for centuries (out with sexrole stereotyping). Within the overall issue of the need for women's voice to be heard in leadership as elsewhere, assumption after assumption is biting the dust in the wake of scholarship disproving sexist assumptions and gender-based prejudices.

But five years on from our main UQ WISTA survey, where are we now on counteracting these assumptions? Whyte recalls in the British GIST project that "teachers need to be convinced of existing bias before they will consider positive action for girls" (Whyte, 1986, p.230). By no means were all of the Deans, Professors, Heads of Schools and Lecturers whom we interviewed convinced even that we were investigating a "real" problem.

> *"But Professor Byrne, you are presupposing that women's lesser enrolment in the physical sciences is a* ***problem*** *in the first place. Why does it matter? If they want to enrol, they will. Why does it matter who our students are?"* (Head of Physics, University, Group Interview, 1985)

He was by no means untypical, although a majority did see an issue to be investigated and dealt with; preferably, however, by others. Some were actively hostile; others became so committed that they have remained in touch and regularly send us material on female achievements in science, to strengthen our argument. In response to the ten Discussion Papers on which we asked for written feedback (available to researchers on demand as Volume III to this Report), we cite below the two extremes. The following arrived from a University Maths Department whose Head had circulated the Papers:

> *"This is, of course, exactly the kind of garbage I associate the feminist movement with, and I hope you do not really expect me to waste my time reading it and trying to figure out what all these nonsensical questions mean! It is bad enough that we have to pay tax so that the government can employ people to produce this sort of rubbish; you can't expect me to also spend time on it. I'll pass it on to the next victim immediately.* (University Lecturer 7/5)

Another Lecturer took a different view on the "feminist garbage":

> *"Thank you for the informative and vigorous WISTA Discussion Papers 7-10. I particularly appreciated their minimal use of jargon."* (University Maths Lecturer, 1/1)

The Paper on prerequisites, in particular, produced serious, constructive comment from most, of which this is characteristic:

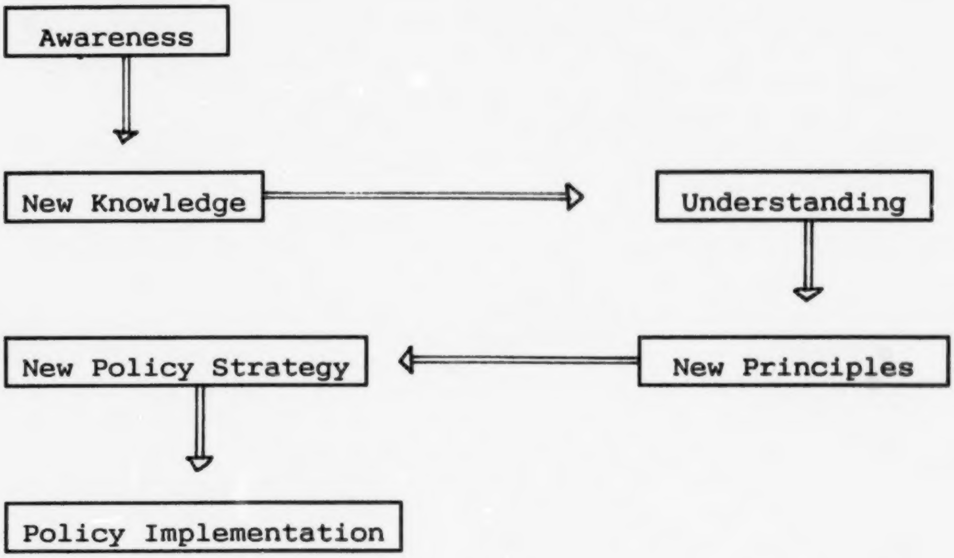
> *"Thank you for this Paper. It addresses issues of relevance and poses important questions."* (Chairman, Academic Board, University 9/3)

We have used material both from group interviews and from written feedback, in relation primarily to five factors: role modelling, mentorship, image, maths as a critical filter, single-sex v. coeducation. The cluster of factors involving prerequisites, attitudes, curricular choices and career education are being pursued in a follow-up project funded by a three-year grant from the Australian Research Council, the SHEP-APIST project (Secondary & Higher Education Policy: Access & Progression in Science & Technology) which runs from 1991-1993.

A strategic approach

One weakness in the 1990s continues to be higher education's continuing lack of a sense of institutional goals as such, *in real terms*, as distinct from paper policy statements and "Educational Profiles". The role of key management personnel (Deans, Professors, Heads of Schools in higher education) in policy issues relating to this area, is confused, ambiguous, highly varied and extremely idiosyncratic in terms of fulfilment of institutional goals (if any), of institutional strategies and of discipline-based responsibilities.

One first task is to persuade the leadership of higher education that ***single dimension strategies do not work*** and that programmes or strategies which use clusters of causally related factors are necessary. This implies some inservice education about cultural and psychological and not only physical or structural aspects of learning environments. The policy process should operate, rationally, as follows:



In practice, higher education has tended to jump from awareness based on unsupported received wisdom (*"role models are important"; "single-sex schools produce more women physicists"*) straight to new policy strategies with scant time to acquire new knowledge or understanding of the research and new theory available, and without seriously debating new principles as institutional goals. The research approach should seek to build back in, new knowledge and increased understanding. Management, good management, should be based on both.

If there had been a simple and inexpensive policy or management solution, of course, it would have been implemented long ago. We have, however, known for twenty years or more of most of the kinds of issues raised by this study. What we have not known, is how much of the received wisdom is either unfounded, or contradictory, or mutually exclusive to other received wisdom. In the impossible task of trying to keep up with escalating research and evaluation, the Snark Syndrome (*"I've said it three times so it's true"*) has sprung up and spread like mint in a herb garden or couch grass in the rose bed.

The arguments advanced in this Report are no more susceptible to irrefutable proof, than the theories we have criticised. It is for the reader to set them against the available data, against reputable substantive theory and against their own real-life experiences. We believe they provide improved explanatory theory. They do, we argue, ring true at the level of grounded theory.

What, then, are we saying?

MANAGING POLICY CHANGE: INSTITUTIONAL ECOLOGY

We have, firstly, argued for a paradigm shift to looking at the institutional ecology as we have redefined it, and not at what is "wrong" with women (blacks, migrants etc). Part of this institutional ecology is the general attitudinal climate towards women. As part of this, we asked for information and/or evidence about institutional policy initiatives on the status of women, affirmative action strategies, the existence and use of women's support networks, and related matters. As at 1985 and 1986, however, most of the action in this area, such as it was, proved to be so recent and new (or even, still in the planning and proposal stage), that it was judged to be invalid as a basis for inclusion as part of the ecology which had actually influenced or determined the position we found in the survey disciplines in 1985 or 1986. Since the survey, the number of initiatives in the area (RMIT's 1986-88 Women in Engineering Project; QUT's affirmative action programme for attracting women to engineering; the University of Queensland's special scholarships to enable mature women scientists to return to professional practice via research scholarships, and so on) has increased steadily.

Because the evidence that reached us gave two different (but co-existing rather than mutually contradictory) pictures, we have written separately on the issues of women's support networks (one of our original ten factors). Some women respondents, from undergraduates and postgraduates to senior academic and professional staff, felt them to be critically influential; others regarded them as perpetuating the image of "women engineers" or "women physicists", undesirably. In practice, they are needed for some young women and not for others. A small minority of articulate, middle class, confident and unusually gifted women engineering students who were the Gold Medallists of whom we were frequently told, took the view that they saw the networks as unnecessary or decisive. But others who were in more aggressively "ocker" Departments or Schools, spoke warmly of the support, encouragement and mentorship that networks which included successful practising women in the field, gave them, which helped them to continue and not drop out. This issue needs further review in the wider context of mentorship.

It is doubtful whether, even in 1992, we are yet at the point where there is sufficient agreement on the diagnosis, to set one cure simply in train. To take stock of the general issues:

- We have argued for a paradigm shift away from single-dimensional projects without roots focussing on women as a deficit model, and towards an institutional ecology approach where powerful men take responsibility throughout the institution for changing male and female attitudes and do not leave it to powerless or minority women in the system.

* We have argued for a new conceptual framework centring on critical mass and on image-based concepts of nontraditionality, sexnormality and genderneutrality as environmental explanations of disciplines as an ecological niche. Not until male staff and students alike cease to transmit concepts of the nontraditionality and sexabnormality of those (of either sex) enrolled in a discipline *below the level of critical mass*, will we make organic, sustained progress.

* We have argued that further research should focus on interdisciplinary and interinstitutional differences, and that "science" or "technology" are unhelpful generalisations. We postulate that some disciplines are more susceptible to institutional influences within its ecology, than others. We need to know why. Professional institutions and associations need to face these issues as well as higher education.

* And we have argued for a holistic or cluster approach in policy projects. To continue to invest millions of dollars in single factor or dyadic one-off models, is a poor return for investment; and wasteful and ineffective. We need institutional change to counteract *genesis amnesia*.

Progress or backlash?

There has, of course, been significant progress across two decades, and it would be simple, and encouraging, to concentrate only on the undoubted gains in women's access to and progression in the different disciplines and arenas over the last two decades, including since the mid-1980s. But it would be deceptive. The real picture is very mixed, and more complex.

For example, in several States in Australia, curriculum development created a new multistrand science, the original purpose of which was precisely to break down the historically inherited and abstract theoretical straitjacket of separate physics and chemistry and natural science and deal with scientific problems in an integrated and more socially relevant way. But the inflexibility of tertiary institutions and the general inertia of the school teaching force (innovators are by definition, never a critical mass!) have combined with parental ignorance and prejudice to relegate multistrand science to the same status as *Maths in Society* as a Grade 12 subject: the fail-safe for the less able. Competition for scarce higher education places with expanding demand has cast a dead shadow over creative curriculum design. The current growth in rationalistic thinking and in competency-based assessment, has the possibility further to inhibit the holistic approach to interdisciplinary curricula which the research literature on adolescent attitudes in schooling, argues would widen girls' choices.

Similarly, assertions repeated three (or thirty) times that we have eliminated the gender gap because overall, women are half of all undergraduates in many countries, or because girls average half of all maths candidates (if we include Maths in Society figures), or because we have a few more women Professors (I am still one of Australia's only 5 per cent of the Professoriate who are female: 9.6 per cent in my University), are as unscholarly, unselective and unsound as the role model or single-sex received wisdom. For while Grade 12 figures since 1985 and 1986 show some continuing small narrowing of the *sex gap* in one or two sciences, and notably in geology, relatively fewer girls as a whole are studying science or technology at all, at Grade 12. In Queensland, the percentage of females as a percentage of all candidates, actually fell from 1980 to 1988 in Maths I and II, chemistry and physics and earth science. Female enrolments even in biology were down 14 per cent over that period. The pattern is replicated in several other States. And the sex gap, while narrower, remains significant. In the late 1980s in Queensland, some 37 per cent of boys but 13 per cent of girls took physics, and 39 per cent of boys, but 24 per cent of girls, chemistry at Grade 12. Clearly, one overriding issue may be the students' perceptions of the future career outlets from different disciplines. The now dramatically higher financial rewards from studying law, medicine, dentistry or computing in Australia, filter many able young people out of pure and applied science or engineering, surveying and mining, into these areas. But in Australia, female veterinary science undergraduate enrolments at Universities have moved from 3 per cent in 1940 through the untypicality band (about 20 per cent) in the early 1970s, to complete genderneutrality (49 per cent women) in the late 1980s. What changed its image? At the same time, when engineering and physics lost ground? The answers are important for economic reasons as well as for equity.

Another backlash area is in computing and computer literacy. Unlike mining, which goes back to the Iron Age as a "masculine domain", and engineering whose male-domination predates the Pyramids, computing as a discipline is less than three decades old. The academic staff participants in the UQ WISTA group interviews tended to describe it as gender neutral but this is incorrect and wishful thinking against the statistical data. The most serious and widespread evidence is of growing gender differentiation in access to computers and in perceptions of computing as user-friendly. The now considerable research literature on computing in education, shows that:

* Parents still buy computers more readily for sons than for daughters: sons also dominate computer-use in the home.

- Boys acquire territorial priority for hands-on work on scarce computers when student numbers exceed available computer hours in school situations.

- Girls are arriving at tertiary level with a narrower (and mainly reproductive) range of computer skills than boys.

- Boys are less willing to work cooperatively on computers than girls: an essential learning process unless and until every student has their own microcomputer.

A very recent British study reports that *"girls tend to be dominated by boys in computer-based tasks which require cooperative work, even though girls have no disadvantages in these tasks when tested individually or in single gender groups... (in measuring) tasks which required the cooperative use of the computer keyboard... both types of single gender pairs improved in comparison with individuals working alone, but mixed gender pairs did not"* (Underwood and McCaffrey, 1990). This issue is, again, really one of ineffective or effective classroom management - principally because school teachers still do not see girls' underachievement as a problem for which they are responsible.

Reconstructing science

It is also clear from a wide range of research and field evidence that unless and until we reconstruct the content and structure of many scientific and technological disciplines, we will continue to lose not only girls, but creative androgynous boys to these. The resultant implications of a future manipulated by theoretical, dehumanised technology controlled mainly or exclusively by the more instrumental and mentally linear of males, is horrifying. A very recent British study of sixth formers (Grades 11 and 12) across six schools and colleges, confirmed the continuing trend that:

> *"Many students had negative attitudes to school science courses... the sterile, impersonal nature of that content in physics and chemistry... The negative attitude of girls to much of school sciences was due largely to its impersonal and abstract nature... the image of scientists portrayed by the media, either as caricatures of the mad (male) scientist or the expert called in to explain away* ***another*** *disaster, also affected student attitudes."* (Woolnough, Brian, 1990, pp.3-4).

Above all, these students were put off by the lack of opportunity for self-expression (too much formulae and multiple choice) and the lack of relationship to the "real human problems of life" (p.7).

- We believe that the evidence of this and other recent studies justifies a major curriculum review of school and tertiary physics, chemistry, geology, engineering and mathematics: to include the production of gender-neutral textbooks, and focussing on material and content on the human and social implications of what is to be taught and learned.

* There is at least some correlational evidence to support a hypothesis that overstructural and inflexible degree courses with little choice, may increase overall dropout and discourage female enrolments.

Role modelling and mentorship

It is clear from our analyses that we believe that our data and analysis justify a major paradigm shift here, in policy terms. Our detailed recommendations are set out in earlier Chapters, and are not repeated here. One must register, however, some incredulity at the ease with which men have (again) persuaded women, even feminists, that all of the extra work needed to help girls and women overcome the barriers that males set in their way, must also be done by women personally giving up time to rush around being "visible" as role models, thus letting men once again off the hook from dealing with male-created problems. Breaking the stereotype must be done through systemic means, videos, publishing. Individual help to girls and young women is mentorship, and the case has been made for this to be seen and acknowledged as part of school, college and university ecology and placed in a policy context for monitoring and development.

Single-sex or coeducation?

The issue may be summed up in the words of a Canadian Grade 10 student in the context of an evaluation of single sex maths classes:

> *"Teenagers should be taught to deal responsibly and maturely with problems involving the opposite sex; not removed from them."* (McFarlane and Crawford, 1985)

While it would be wrong to underplay or underreport the undoubted problems which ocker (uncouth, contemptuous, arrogant...) male peer behaviour creates for girls in school classrooms, it is clear that the whole single-sex issue is a classic of received wisdom with an unsound research base. Our argument is to deal with the real problems head on, and not by (yet again) asking girls to take evasive action, leaving boys to remain unsocialised with impunity.

Maths as a critical filter

Similarly, it is pointless to continue simply to blame the schools, however rightly, either for incompetent teaching or for gender conditioning. Schools are by their nature inertia-prone and systemic change is slow, even if we had the maths teachers. While we continue to research at school level to unpeel the processes that filter girls out from applied maths and pre-technology maths, we need tertiary bridging programmes funded by governments (in Australia, by the Federal Government) to provide the missing maths either in one-semester bridging courses or in the first tertiary year. And not single-sex classes!

We might, perhaps, illustrate the principal issue, by telling the story of one of the group interviews in 1986. After having read the first four Discussion Papers in advance, and listening to the group discussion of the issues raised, a Professor from a discipline in which girls were barely into the "abnormal/rubric of exceptions" minority, said:

> *"Professor Byrne, I have a problem. You are two women directing this project. Do you not think this invalidates the results?"*

After a moment's stunned silence, I said,

> *"Professor X, let me be clear what question you are asking. You are saying that because we do not have a mixed-sex research team, our research into these issues is invalid? Presumably you will accept that, then, 90 per cent of scientific research so far is invalid because it has been conducted exclusively by men?"*

He shook his head uncertainly.

> *"I'm sorry. You are saying that because we are women, we are less able or well qualified and need what Simone de Beauvoir termed 'a male mediator between us and the Universe'?"*

He hastily protested that our qualifications and experience were impressive.

> *"I am sorry to have misunderstood again. You are saying that because we are women, even if our research is in fact sound, no one will listen to us, simply because we are women?"*

As he struggled to come to terms with that, a colleague came to his rescue.

> *"I think what my colleague is saying, Professor Byrne, is that it would be a pity if so much wide-ranging and substantially funded research on so important an issue, were not influential because..."*

His voice died away. I said quietly,

> *"So you are in fact saying that he believes that however right women are, they cannot be listened to with the same scholarly clout as men?"*

He said curiously,

> *"What will you do, if that happens?"*

I said promptly,

> *"Go on television and radio, since I do a good deal of media work already, and recount this conversation, as representing part of the essence of the central and real cause of the whole problem we have been investigating."*

He looked at me thoughtfully.

> *"Professor, five minutes ago, I would have said that I would be up there with you - but let me not suggest that you need a male mediator! So I will rephrase it and say that I will be there supporting you from the wings... You should do just that."*

Perhaps the classic example of cultural devaluation of women's relation to science, can be seen in Anne Sayre's corrective biographical account Rosalind Franklin and DNA in which Sayre records her view that "(Rosalind) has been used, thanks to *The Double Helix*, to menace bright and intellectually ambitious girls", and goes on to spell out how, including the use of Watson by anti-feminists. The central issue is that the teaching of science has not only been imaged as masculine and based on masculine culture, but is historically incomplete or misrepresentational on the role of women scientists in the last twenty centuries, and notably in this one; a role still largely unacknowledged in tertiary teaching and texts.

This research is still only one step towards correcting the culture as well as the practices. It should be seen as a (we hope significant) phase in a continuing research dialogue, rather than a conclusive outcome. We hope that more leaders in Universities and other tertiary institutions, will be encouraged to pursue that dialogue - and to own it, as a basis for more proactive policies.

REFERENCES

McFarlane, S. and Crawford, P. (1985) "Effect of Sex Segregated Maths on Student Attitudes and Achievement in Mathematics", Research Report, ERIC ED276 734.

Underwood, G. and McCaffrey, M. (1990) "Gender Differences in a Cooperative Computer Based Language Task" in **Educational Research**, Vol.32(1), Spring.

Whyte, Judith (1986) **Girls into Science and Technology**, Routledge & Kegan Paul, London.

Woolnough, Brian (1990)(Edit) **Making Choices: An Enquiry into the Attitudes of Sixth Formers towards Science and Technology**, Oxford University, Department of Education.